HYDROLOGIC STUDIES OF

EFFECTS OF CONOWINGO DAM

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SUSQUEHANNA RIVER BASIN COMMISSION

TECHNICAL REPORT NO. 1

NOVEMBER 1979

ACKNOWLEDGEMENTS

The authors would like to acknowledge the assistance of many members of the Commission staff in making this study. Special recognition is extended to Dr. E.E. Seay, Commission Staff Economist, who made the analysis of the financial impact of the minimum release scheme, while Mr. Dennis Stum, Civil Engineer, performed much of the computer analysis and developed the graphs and tables. Also, Mr. Gregory Senko and Mr. Stanley Rudisill of the Commission staff helped with the collection and analysis of the fishery information, which led to the recommended release schemes, and Mrs. Karen Shambaugh accomplished the typing.

The authors also acknowledge the contribution of Mr. W.R. Carter, III, and John W.S. Foster, III, of Maryland Wildlife Administration, Mr. Fred Johnson of Pennsylvania Fish Commission, and Mr. Richard McCoy, Mr. Steven Goodbred, and Mr. Gerald Taylor, U.S. Fish and Wildlife Service, in the collection and analysis of fishery information.

ABSTRACT

The results of two different types of investigations made regarding the effects of Conowingo Dam on the hydrologic regimen of the Susquehanna River are described. The first type of study was statistical in nature. It was designed to determine whether flow data was consistent among different points along the Susquehanna River, and to determine the historical effect of Conowingo project operations on flows. The results showed that the flows are generally consistent, and the Conowingo Dam generally affects low flows, particularly flows less than the capacity of one turbine.

The second type of investigation was a simulation analysis to demonstrate the effects of different continuous release schemes on all uses of the Conowingo pool. Various release schemes were considered. A study of flow needs for the fishery was conducted and is described in a separate report. Based on that study several different flow release schemes were recommended by fishery agencies. The effects of these fishery based release schemes are relatively similar. The financial impact of one of these schemes was estimated and found to be insignificant to the ratepayer.

Effects of Baltimore water supply withdrawals were evaluated and found to be minor on the average, but highly significant during low flows.

Finally the effect of installation of additional turbines in 1964 was evaluated and found to have a significant effect on dewatering the areas downstream of the dam.

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

LIST OF FIGURES

LIST OF FIGURES
(Continued)

LIST OF FIGURES
(Continued)

LIST OF TABLES

LIST OF TABLES
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HYDROLOGIC STUDIES OF EFFECTS OF CONOWINGO DAM

I. INTRODUCTION

There are four hydropower generating facilities located on the Susquehanna River downstream from Harrisburg. They are (in downstream order) York Haven, Safe Harbor, Holtwood and Conowingo. The objectives of our studies were to demonstrate:

1. The effect of the operation of all four dams on flows, and particularly low flows in this portion of the river.

2. The effect of future withdrawals from the Conowingo pool for municipal water supply, power cooling and power generation, combined with different operating schemes for Conowingo Dam.

3. Certain effects of imposing minimum release requirements on other uses of the projects.

This report presents the methodology used and the results of those studies as they pertain specifically to the Conowingo Project, and presents Commission staff conclusions based on the studies.

II. DATA COLLECTION

Commission staff attempted to obtain a complete set of daily inflow and outflow data for Conowingo pool for the period 1961-1974 from the Philadelphia Electric Company. Philadelphia Electric Company furnished the inflow data for the entire year, but requested that the amount of outflow data be minimized because it was necessary to tabulate that data by hand. After reviewing our needs and discussing the problem with the State of Maryland, we decided that daily outflow data for the period from March 1st to November 30th of each year would be sufficient, since that period would include both the fish spawning season and the low flow period. The Philadelphia Electric Company then furnished that outflow data. Both sets of data were punched on computer cards and inserted into the WATSTORE computerized data files at the USGS National Center in Reston, Virginia. The data was then retrieved from these files for further processing.

In addition, daily flow values for the USGS gaging stations at Harrisburg (USGS No. 01570500) and Marietta (USGS No. 01576000) for the period March 1st through November 30th, for each year between 1961 and 1974 were retrieved from the WATSTORE files. Also, daily flow data for the USGS station immediately downstream from Conowingo (USGS No. 01578310) for the period March 1st through November 30th for each year between 1967 and 1974 were retrieved from the WATSTORE files. There are no records available for the latter station prior to 1967.

In summary, four sets of daily flow values covering the period March 1st through November 30th for each year from 1961 through 1974 were available. Data for the period March 1st through October 31st were actually used in the analyses, except for the correlation studies which used data for part of November. These are designated Harrisburg, Marietta, Conowingo Inflow and Conowingo Outflow. A fifth set of daily flow values was obtained for the Conowingo USGS station for the period March 1st through November 30th of each year through the period 1967-1974.

III. THE EFFECT OF DAM OPERATION ON HISTORIC FLOWS

A. Problem Definition

The flood insurance studies performed by the Commission staff downstream from Conowingo Dam showed major discrepancies between Philadelphia Electric Company and USGS rating curves at high flows. Furthermore, the staff has pointed out on previous occasions that the historic minimum daily low flow at the Marietta gage is less than the corresponding flow at Harrisburg. Also, certain low flow characteristics are different at Marietta than at Harrisburg. The staff suggested that this was due to the operation of York Haven Dam. The response from the power companies noted that there was insufficient storage available in the reservoirs formed by the power dams to affect flows, and therefore, there must be some problem with the data. Because of these questions, it was necessary to examine the flow data to determine whether there were major inconsistencies in the data and to determine which set of data should be used for the study of effects of future flow conditions. If the data is not consistent between stations, comparisons of daily flows are not valid nor are comparisons of flow duration and low flow frequency curves.

In order to study this question, the staff hypothesized that the daily flow data is consistent between Harrisburg, Marietta, Conowingo Inflow, Conowingo Outflow, and Conowingo USGS data. The hypothesis implies that Conowingo Outflow and Conowingo USGS data are basically consistent. Inconsistency of the data may be displayed either in mean flows over a given period of time or by different patterns of the serial correlation and cross correlation coefficients between stations. If the data is consistent between stations, both the monthly mean flows and their respective variation between successive months for each year should be the same except for the effects of increased drainage area between stations. If there is a significant error in a portion of the rating curve at one station, that error should show up as a difference in the monthly mean value at a level of flow corresponding to the flow at which the error occurs in the rating. Similarly, incompatibility of data may ap-

pear in the serial correlation coefficients as a greater degree of persistence at one station as compared to another, and in low cross correlation coefficients between stations. The analysis of correlation coefficients is confounded by time of year and by natural lags caused by travel time within the reach. Thus, it is necessary to carefully examine the correlation coefficients for different months and lags.

The second hypothesis is that the effect of the power dams is to decrease low flows, but high flows are unaffected. The power companies claim that there is insufficient storage in the power dams to affect flows. The discrepancies in daily flows and low flow characteristics between Harrisburg and Marietta have been noted above. Such discrepancies can be explained either by inconsistencies in the data, relatively large losses between Harrisburg and Marietta, or by the operating rules for York Haven Dam. It is also known that Conowingo power plant is shut down much of the time on weekends during the low flow season, which implies that there is little or no outflow for two days per week under certain conditions.

This hypothesis can be evaluated by examination of standard deviations of flows for each month since the standard deviation of flow in the low flow period will be greater than during the high flow period if there is an effect due to regulation. Also the standard deviations of flows in the low flow months should be greater for stations affected by regulation in comparison with unregulated stations. The regulation effect will not necessarily show up in monthly means because the total inflow should equal the total outflow. Also, the effect of regulation on low flows may show up as a low coefficient of cross correlation for zero lag during low flow periods, compared with high flow periods. Finally, the effect of regulation can be shown by comparison of flow duration and low flow frequency curves, given that the data is consistent between stations. The flow duration curve should show that the outflow from Conowingo approaches zero for a certain percentage of time. Thus, the lower end of the flow duration and low flow frequency curves for Conowingo Outflow should be much steeper than for Harrisburg for example.

B. Statistical Analysis

1. Computational Procedures

The monthly means and standard deviations were computed for each month, each year, and each site being studied, using equations (1) and (2)

$$\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i \qquad (1)$$

$$s = \frac{1}{n-1} \left\{ \sum_{i=1}^{n} (x_i - \bar{x})^2 \right\}^{\frac{1}{2}} \qquad (2)$$

where n is the number of days in a given month and x_i is the daily flow for the ith day of the month.

The ratio of the standard deviation to the mean for any specified sample is defined as the coefficient of variation or

$$CV = \frac{s}{\bar{x}} \qquad (3)$$

The coefficient of variation is used to study the relative magnitude of the variability of daily flows when the means are nearly constant between sites but variable with time. Thus, a large difference in the coefficient of variation between sites for a given month indicates that something is happening between those sites which changes the relative variability of daily flows. The coefficient of variation is used instead of the standard deviation because the standard deviation varies with level of flow, i.e. with the absolute magnitude of the mean flows.

The cross correlation coefficient r_{xy} (L) between two sets of data x_i and y_i is defined as

$$r_{xy}(L) = \frac{1}{n} \sum_{i=1}^{n} \left\{ (x_i - \bar{x})(y_{i+L} - \bar{y}) \right\} / (s_x s_y) \qquad (4)$$

where L is the lag. If L = 0, the cross correlation coefficient represents the correlation of the flows on the same day at both sites. If L = 1, the correlation coefficient represents the correlation of flows at one site with flows occurring one day later at the other site.

The serial correlation coefficient is the value of r_{xy} (L) computed when x and y are the same set of data. Then r_{xx} (0) should always be unity. However, the definition of the standard deviation (equation (2)) was selected so as to provide unbiased estimates (1). The cross and serial covariances were defined so as to provide minimum variance estimates which is the cross product divided by n (2). Therefore, the cross and serial correlations are biased by a factor of $\frac{n-1}{n}$ and the correlation of lag zero ($r_{xx}(0)$) will be less than unity. This should cause no difficulty for the present purpose as long as the definitions are clear.

The monthly serial and cross correlations were computed for lags of zero to seven for each pair of stations in the downstream direction. The length of each monthly series was kept

constant by using values for the following month. The values of the mean and standard deviation were adjusted to account for changes in the lagged series over time.

Several combinations of series were considered. The most basic was daily series for each month for each 8-month year. The second was the pooled daily values for each month averaged across the 8 months for the 14 years of data (7 years for the Conowingo USGS station). The third type of series is the total 8-month series (March through October inclusive) for each year.

To determine the changes of mean daily rover flows in a downstream order, the difference between an upstream site (x) and downstream site (y) was computed as

$$\triangle i = (x_i - y_i) \tag{5}$$

Then the mean and standard deviation of these differences across the entire 8-month period for each year was computed. By virtue of the definition this series of differences should contain all negative values if the downstream series is, on a daily basis, larger than the upstream series. Correlations of these differences with Harrisburg flows were also computed but the resulting correlation coefficients could not be interpreted in a clear and unambiguous fashion, and so these correlations were not considered further.

The above computations were programmed for the IBM 370/155 computer at the U.S. Geological Survey National Center in Reston, Virginia. The computer program is written in Fortran IV language. In general, the computations were performed by entering the job using a Hewlett Packard 9830 programmable calculator operating as a low speed terminal, and then routing the printout to the high speed terminal at the U.S. Geological Survey office in Harrisburg.

2. Analysis of Monthly Mean Values

Figure 1 shows the monthly means for 1964 at the four locations for which data is available for that year. This plot is reasonably typical of all years analyzed. Notice that Harrisburg has a slightly smaller monthly mean than the other stations for all months. Notice that the Conowingo Inflow and Conowingo Outflow are essentially identical on this graph, which is to be expected. Notice that the Marietta monthly means are slightly greater than the Harrisburg and Conowingo monthly means except for July and September. Notice that during the periods of lowest flow all four curves become essentially identical.

Figure 2 is similar to Figure 1 but shows monthly means for 1972. Again, the monthly means are larger at Marietta than

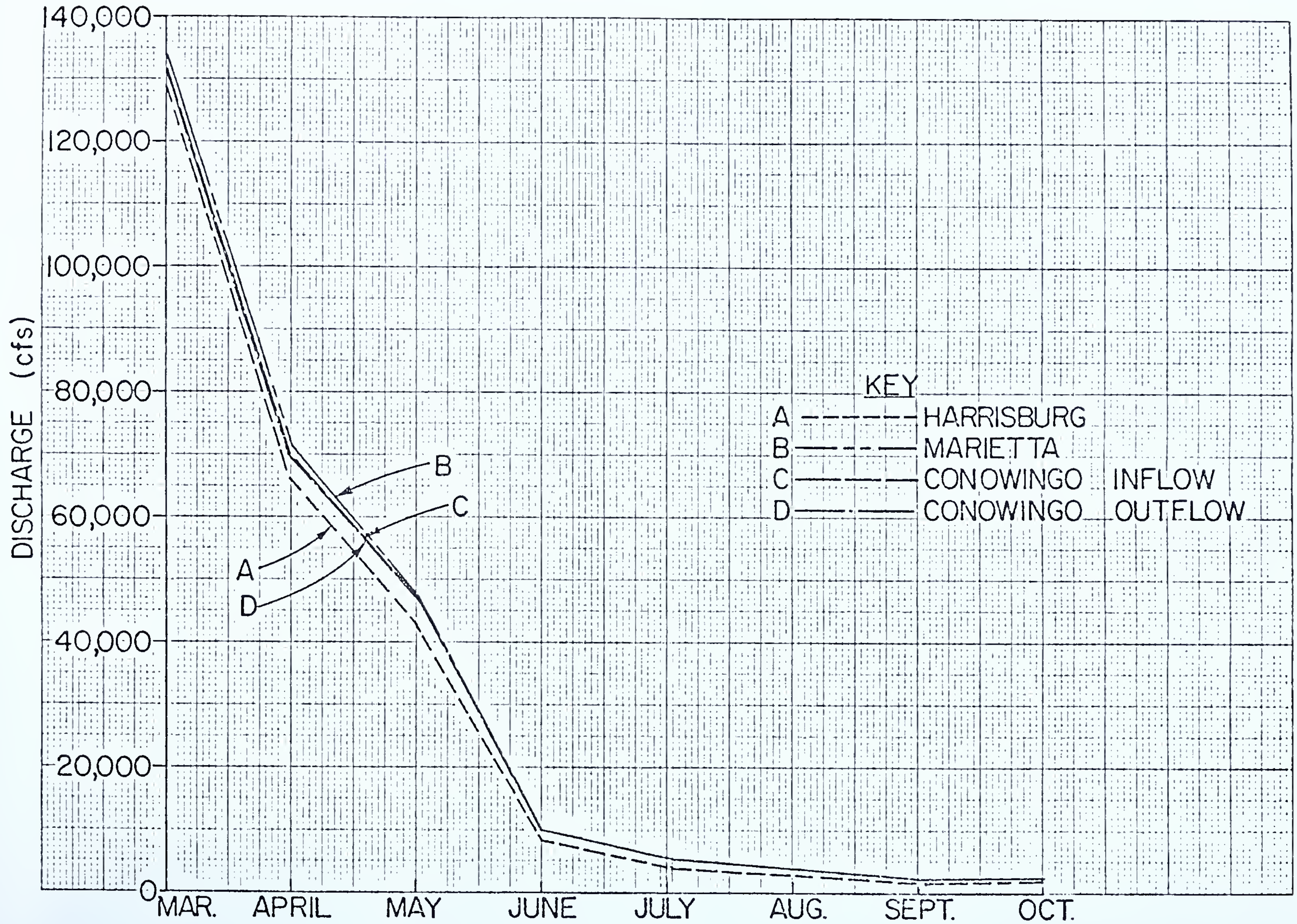

FIGURE 1
1964 MONTHLY MEAN FLOWS

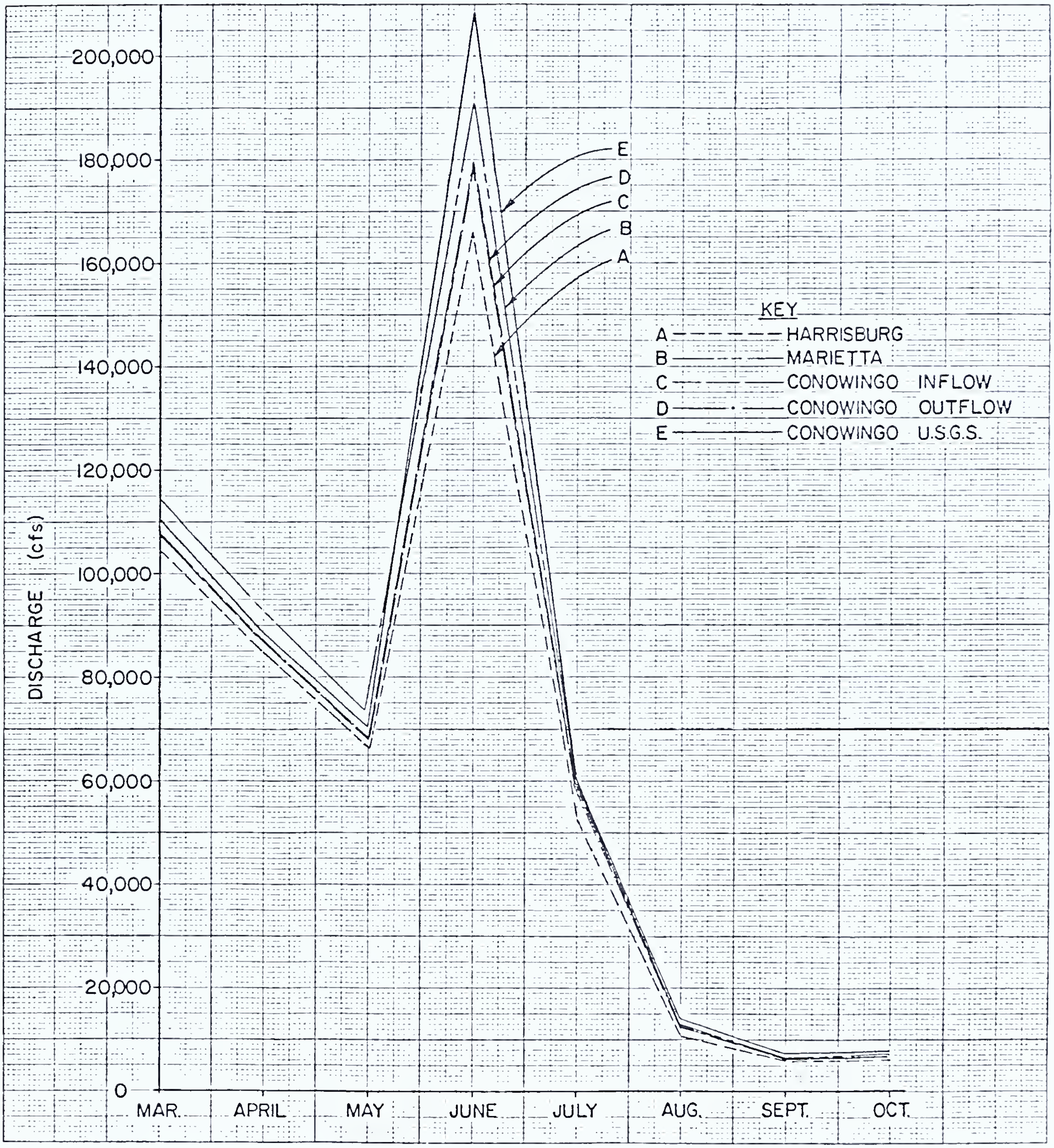

FIGURE 2
MONTHLY MEAN FLOWS 1972

at Harrisburg and the Conowingo Inflow and Conowingo Outflow means are essentially identical. The Conowingo Inflow and Conowingo Outflow values lie below Marietta but still above Harrisburg. The reason for this anomaly will be discussed subsequently. Of greater concern is the fact that the Conowingo USGS station values are greater than the Conowingo Outflow values especially during the high flow period. This confirms our previous experience that the Conowingo USGS rating tends to give higher discharges for a given stage than the Conowingo gate rating curves. Again reasons for this anomaly will be discussed subsequently.

3. Analysis of Coefficient of Variation

Figure 3 shows the monthly coefficient of variation for 1964. Notice that the coefficient of variation is essentially identical for all four stations during the high flow months, and very similar for Harrisburg, Marietta and Conowingo Inflow throughout 1964. However, Conowingo Outflow shows considerably greater relative variability of flow during the low flow months than any of the other stations.

Figure 4 shows the monthly coefficient of variation for 1972. Again, the curves are essentially identical during high flow periods and the curves for Harrisburg, Marietta and Conowingo Inflow are essentially identical for the entire year. However, the Conowingo Outflow and Conowingo USGS station show greater variability during the low flow months than the other three stations. It is interesting to again note the differences between the Conowingo Outflow and Conowingo USGS stations. The variation between the two stations shows here during the low flow months. This contrasts with the mean values, where the differences between these two stations are most pronounced during the high flow months. These differences may be due to the plotting scale, but it appears that the difference between the two stations involves more than a shift in the rating curve.

4. Analysis of Cross Correlation Coefficients

Figure 5 shows lag zero cross correlations for each month for each of six interaction pairs as shown in the key. The confidence bands for rejection of the null hypothesis that the correlation is equal to zero at the 5% level of significance (two-sided student-t test with 28 degrees of freedom (3)) are also shown. These confidence bands show that the lag zero cross correlation coefficients are significantly different from zero except for the correlation between Harrisburg and Conowingo Outflow, Marietta and Conowingo Outflow and Conowingo Inflow and Conowingo Outflow during the low flow months. Notice the high degree of correlation between Harrisburg and Marietta during all flow periods.

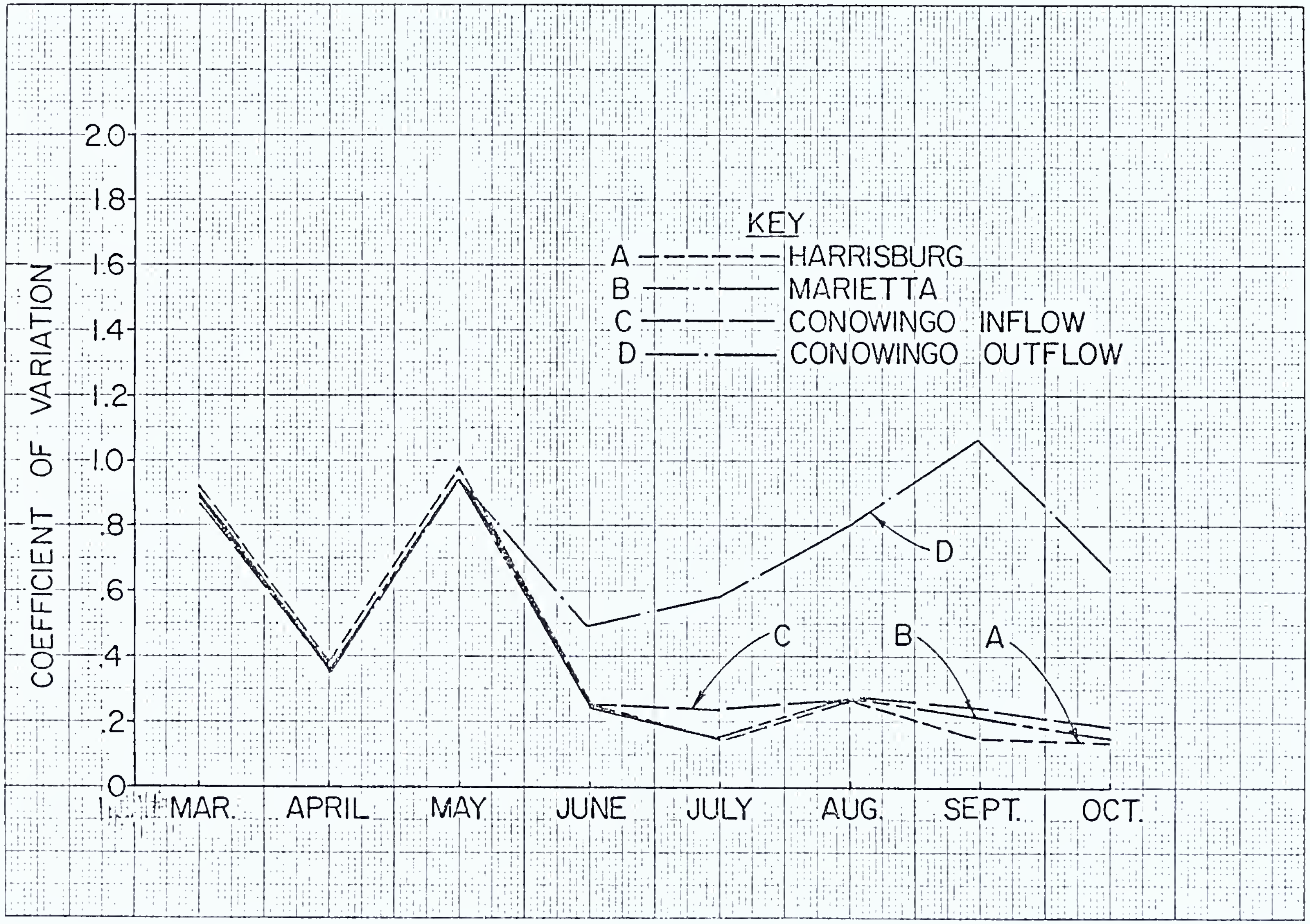

FIGURE 3
COEFFICIENT OF VARIATION OF DAILY FLOWS
FOR MONTHS OF MARCH THRU OCT. 1964

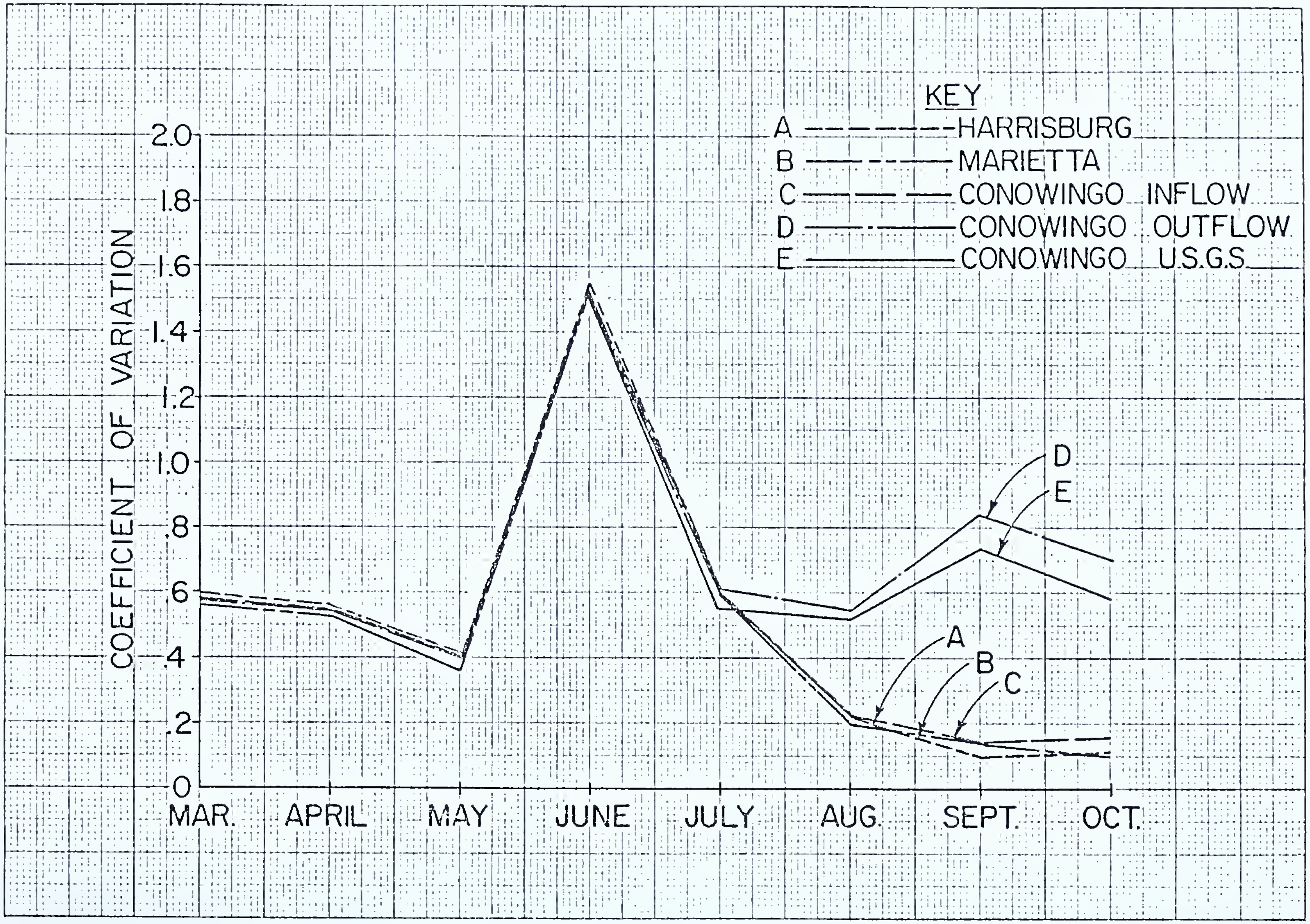

FIGURE 4
COEFFICIENT OF VARIATION FOR DAILY FLOWS
FOR MONTHS OF MARCH THRU OCTOBER 1972

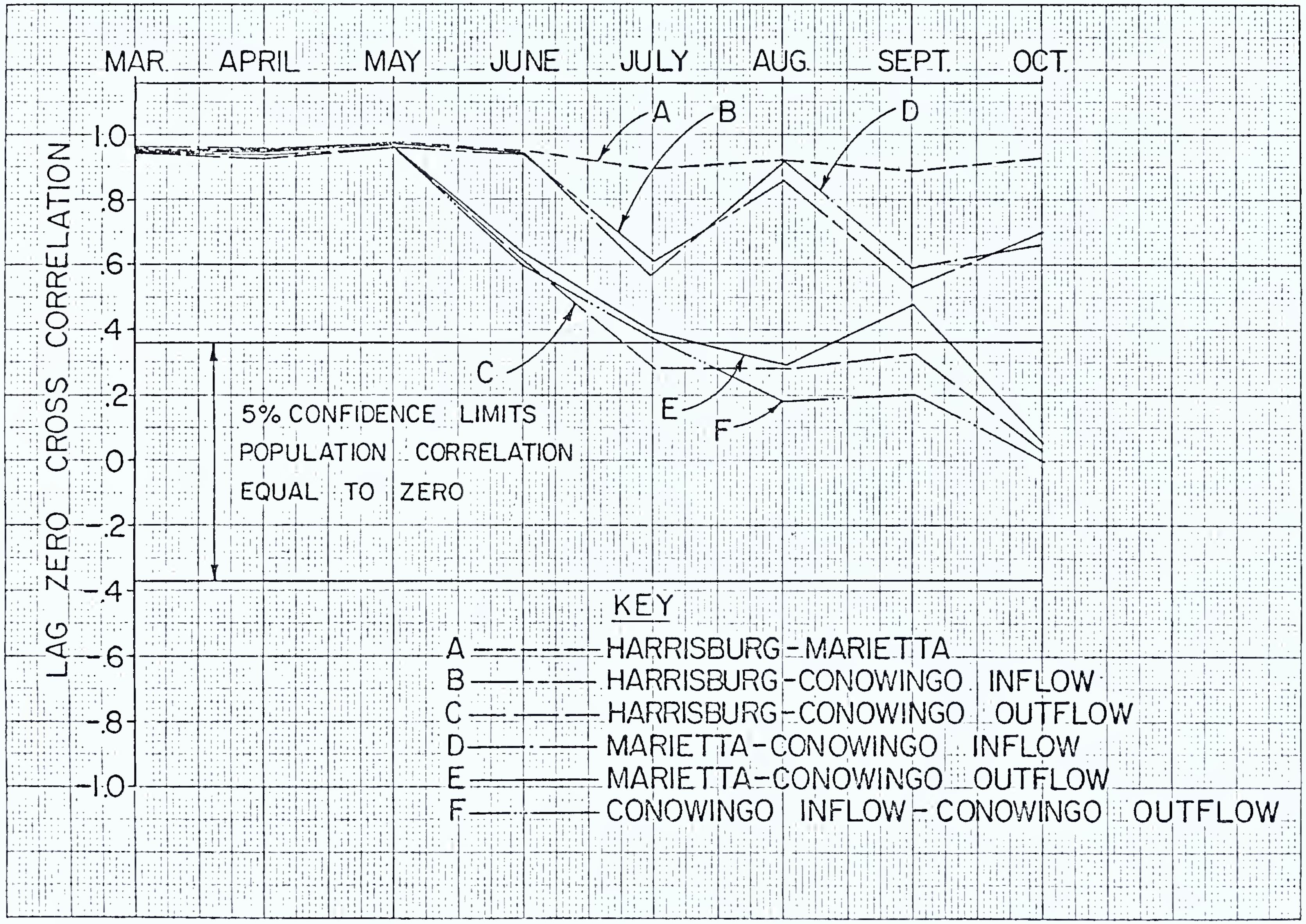

FIGURE 5
LAG ZERO CROSS CORRELATIONS OF DAILY FLOWS
FOR MONTHS OF MARCH THRU OCTOBER 1964

Figure 6 shows similar information for 1972. Again, the lag zero cross correlations are significantly different from zero for all stations during the high flow months, for all combinations of Harrisburg, Marietta and Conowingo Inflow, and for Conowingo Outflow and Conowingo USGS during all months. However, the correlations decrease substantially for all combinations involving Harrisburg or Marietta with either the Conowingo Outflow or Conowingo USGS station during low flow months.

It should be stated that the correlation coefficient as computed defines a linear relationship between flow values at the respective stations. A low correlation says only that the linear relationship between the two variables is small, but there still may be a nonlinear relationship which has not been studied.

A plot of correlation coefficient versus lag is called a correlogram. It shows the degree of persistence in the flows over periods of several days. The correlograms for the Harrisburg-Marietta combination for 1964 and 1972 are shown in Figures 7 and 8 respectively. Notice that the correlation decreases rapidly with increasing lag for all months except May in 1964 and for all months except July and August in 1972. Since the lag zero cross correlation is almost always greater than the correlation coefficient for larger lags, we believe that the effect of natural lag due to time necessary for water to flow from Harrisburg to Marietta to Conowingo is relatively insignificant for the present purpose and that the analysis of correlation coefficients can be based on the lag zero cross correlation coefficients. This opinion is further verified by the correlogram of serial correlation coefficients which shows a similar pattern to the cross correlation coefficients.

A correlogram of pooled cross correlations is shown in Figure 9. These correlations are computed by pooling the correlation coefficients for each month across the years of data so that the correlation coefficient for a given month and lag represents the average value for that month. In all cases, the average month is more stable than the corresponding month in a given year in that the correlation coefficient decreases less rapidly with lag.

5. Analysis of Differences Between Daily Flow Values

Figure 10 presents the mean difference between daily flow values for the 8-month period March 1st through October 31st for each year 1961-74. The differences are computed in accordance with equation (5) and the mean is computed in accordance with equation (1) where n is the total number of days in the 8-month period and x_i is equal to Δ_i. Since the differences are computed by subtracting a downstream flow from an upstream flow, the individual daily differences and, therefore, the mean dif-

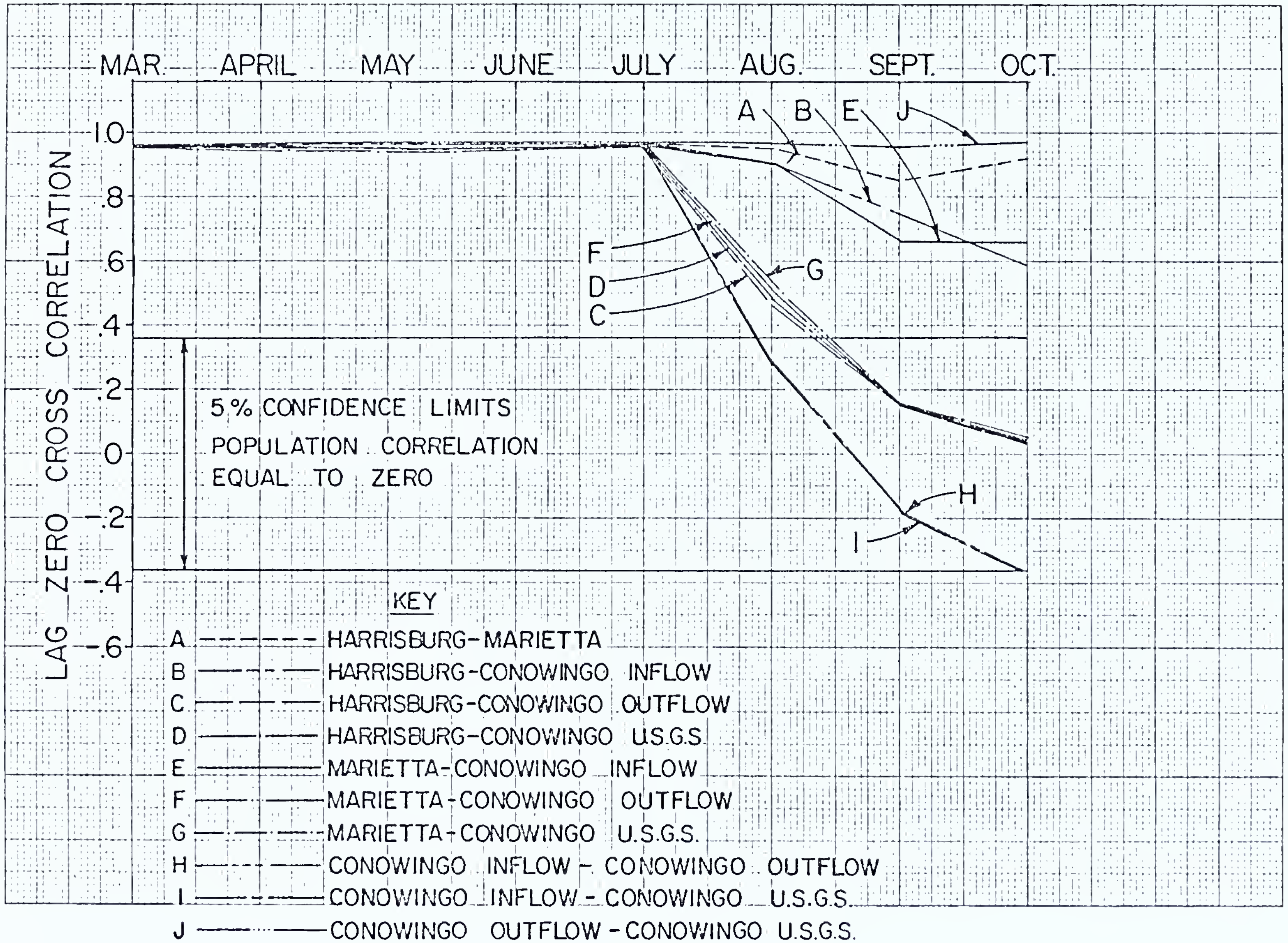

FIGURE 6
LAG ZERO CROSS CORRELATIONS OF DAILY FLOWS
FOR MONTHS OF MARCH THRU OCTOBER 1972

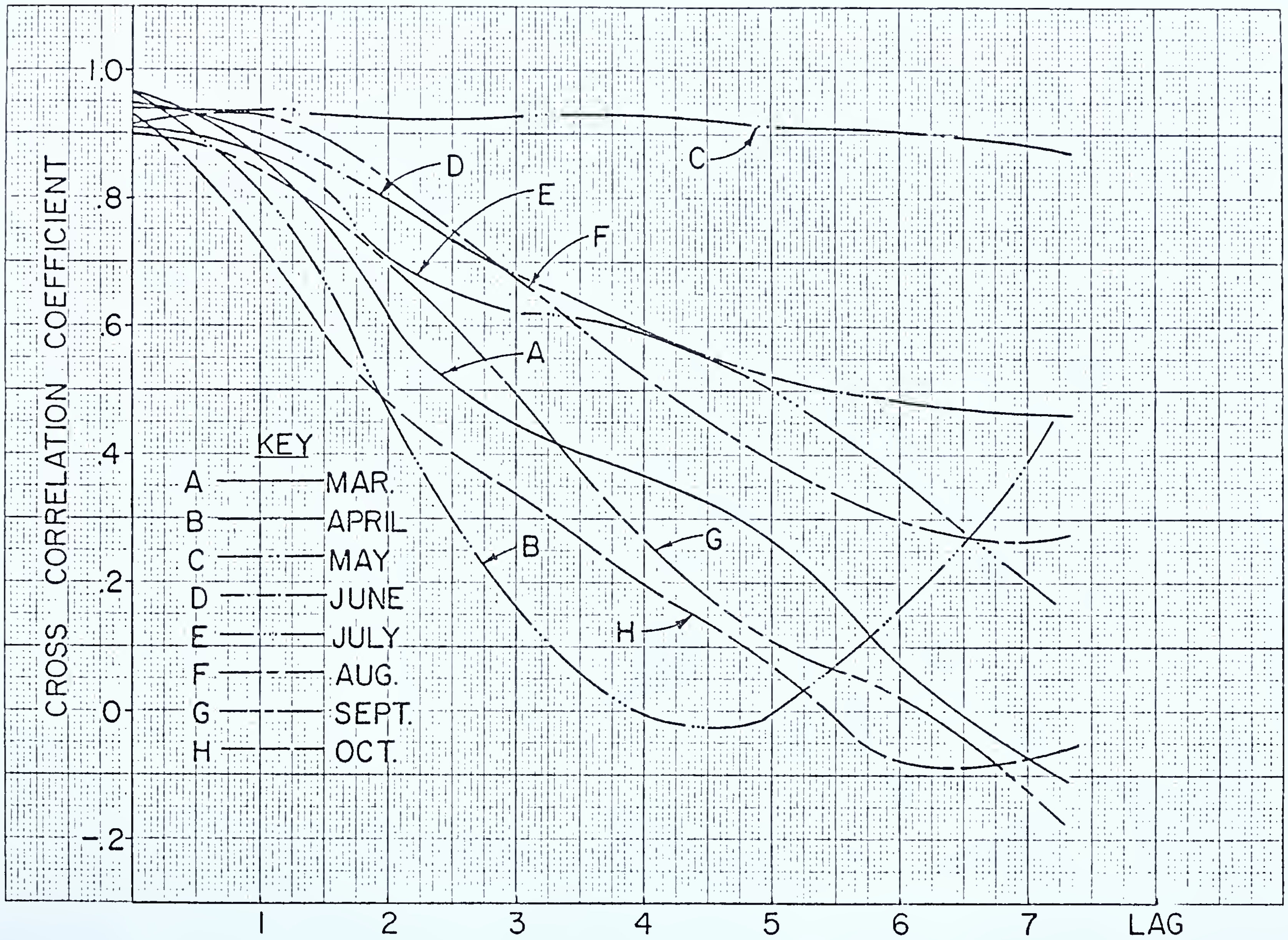

FIGURE 7
CROSS CORRELATION COEFFICIENT VS.
LAG HARRISBURG-MARIETTA 1964

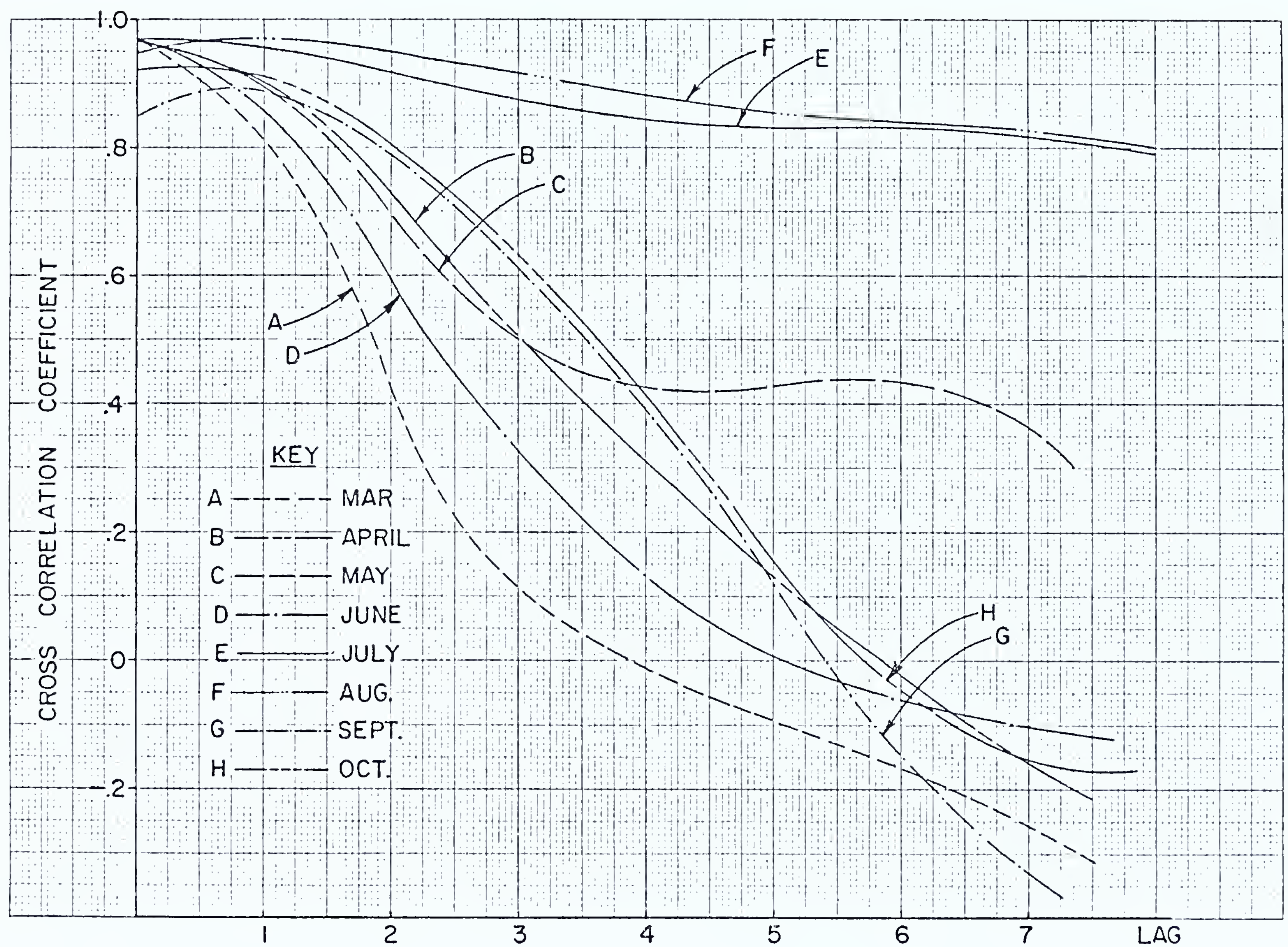

FIGURE 8
CROSS CORRELATION COEFFICIENT VERSUS LAG
FOR EACH MONTH FOR HARRISBURG-MARIETTA 1972

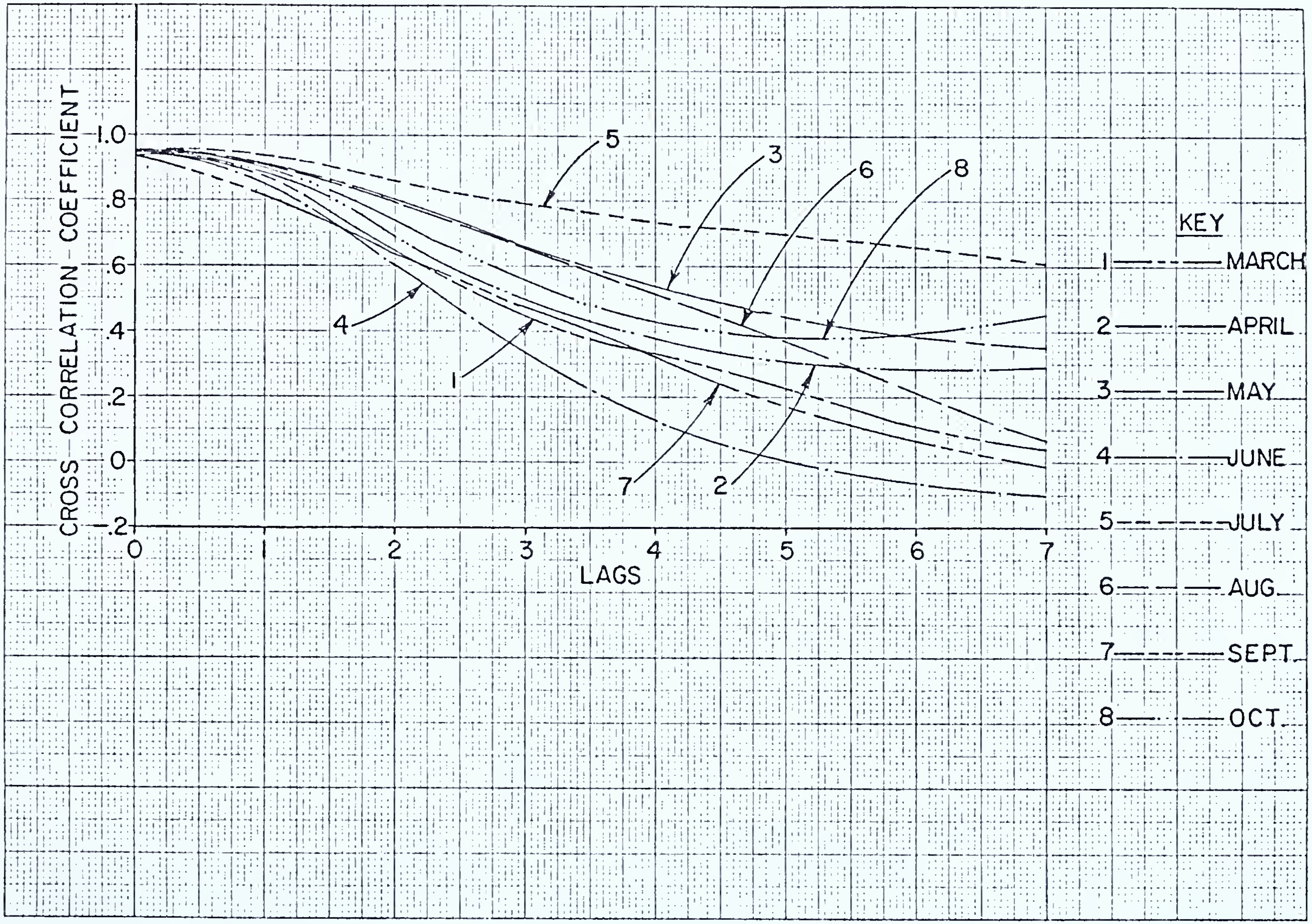

FIGURE 9
POOLED CROSS CORRELATIONS OF DAILY FLOWS
BY MONTHS-HARRISBURG-MARIETTA 1961-1974

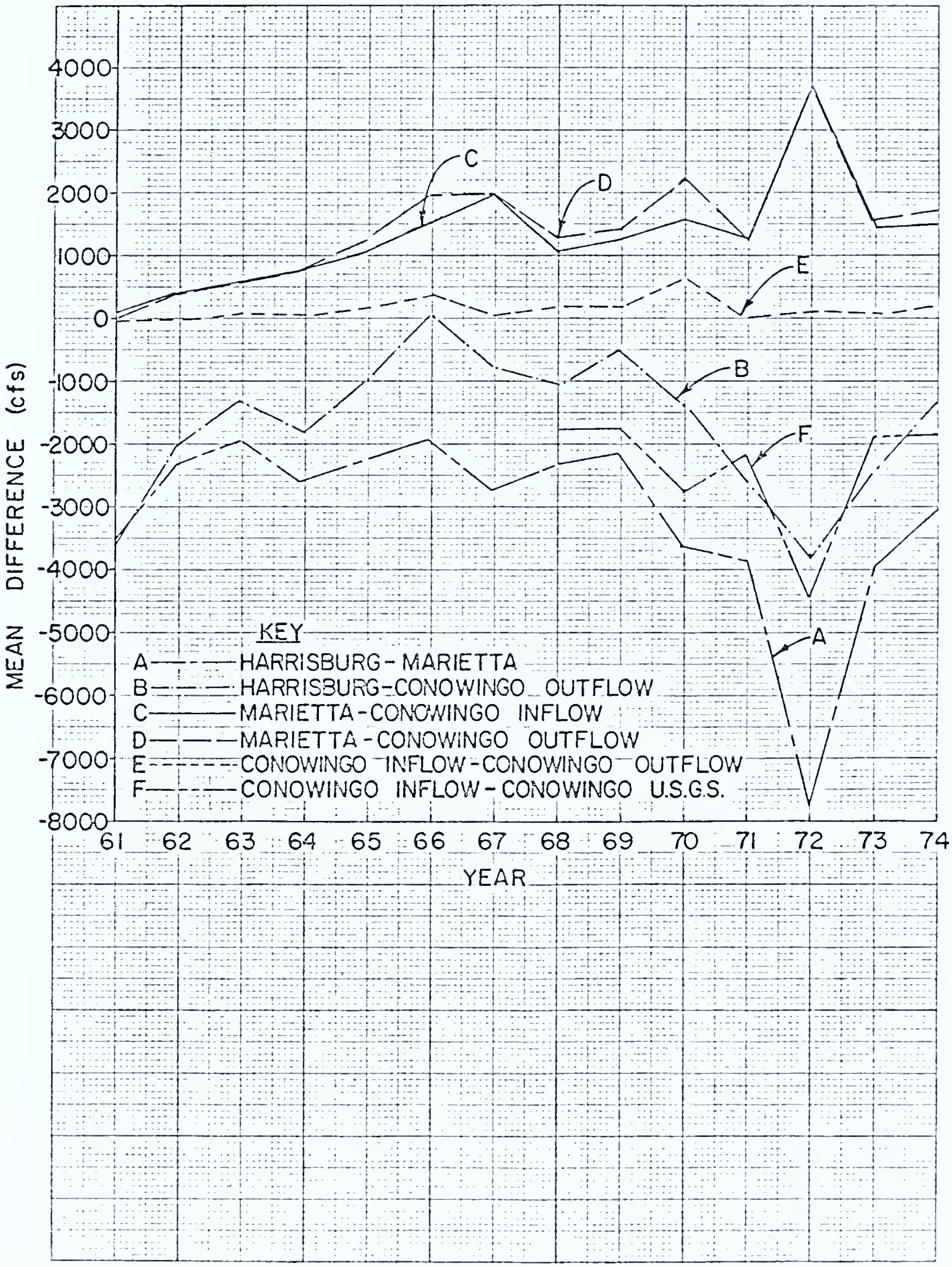

FIGURE 10
MEAN DIFFERENCES BETWEEN DAILY FLOW VALUES
MARCH 1 THRU OCT. 31 IN EACH YEAR SHOWN

ference, should be negative unless a diversion or some other process involving loss of water is present. Notice that the differences between Marietta and Conowingo Inflow (Curve C), the differences between Conowingo Inflow and Conowingo Outflow (Curve E), and the differences between Marietta and Conowingo Outflow (Curve D) are positive, representing an average loss of flow of as much as 3500 cfs over the 8-month period depending on the year. Notice also that the differences between Conowingo Inflow and Conowingo USGS (Curve F) are negative, indicating that either the Conowingo Inflow is underestimated or the Conowingo Outflow based on the USGS record is overestimated by between 2000 and 4000 cfs averaged across the 8-month period, again depending on the year. Note also, that the Conowingo Inflow and Conowingo Outflow appear consistent in a downstream fashion.

The mean difference for a given year and pair of locations can be expressed in terms of the ratio to the 8-month average flow at the downstream station of the pair and then plotted against years as shown in Figure 11. Notice that there is approximately a 9% increase in flow between Harrisburg and Marietta for each year which corresponds roughly to the increase in drainage area which is about 7%. In contrast curve 3 of Figure 11 shows a decrease in flow between Marietta and Conowingo Inflow of between 1% and 6% and an additional decrease of between 0.2% and 2% between Conowingo Inflow and Conowingo Outflow. The difference between Marietta and Conowingo Outflow (Curve 4) is between 0% and 8% of the Conowingo Outflow depending on the year. Notice that the losses are somewhat smaller during the years 1961-64 than in the later years. The significance of the apparent sudden change in percent loss is now known.

The coefficients of variation for these same differences between dialy flow values are shown in Figure 12. Notice that for most cases, the coefficient of variation is nearly constant and relatively small which indicates that the differences between stations are nearly constant between years as well as within years. The major exception is the large value of the coefficient of variation for differences between Conowingo Inflow and Conowingo Outflow. Note the variability of this coefficient of variation between years. The coefficient of variation of these differences approaches 200 times the mean difference in 1964, which is a low flow year. This implies that the standard deviation of the differences is about 200 times the mean difference for that particular year.

The other major exception is the case of the difference between Harrisburg and Conowingo Inflow in 1966 which suggests that there was some major but temporary change in the relationship of flows at these two locations in that particular year.

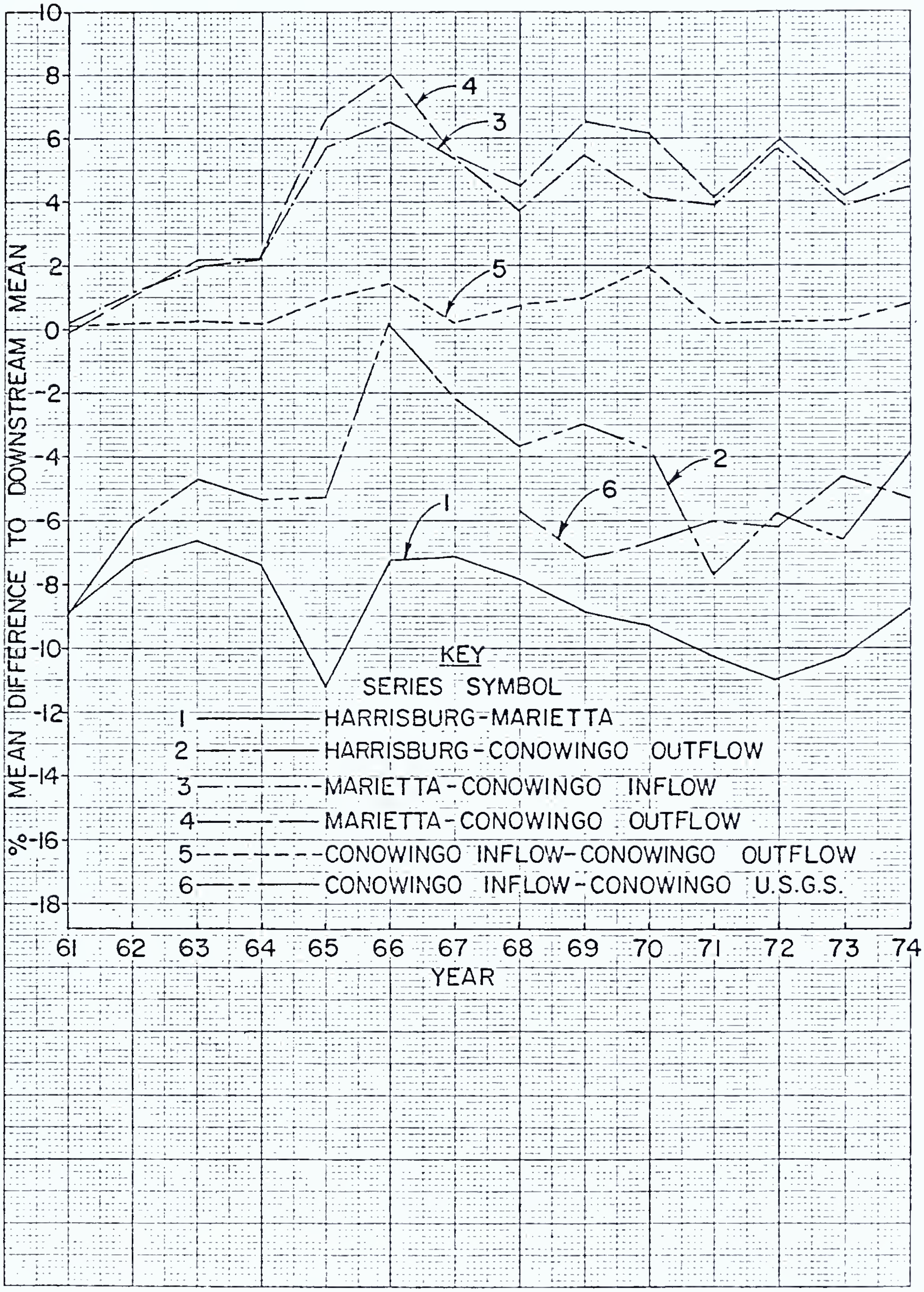

FIGURE 11
RATIO OF MEAN DIFFERENCE TO
MEAN FLOW AT DOWNSTREAM STATION

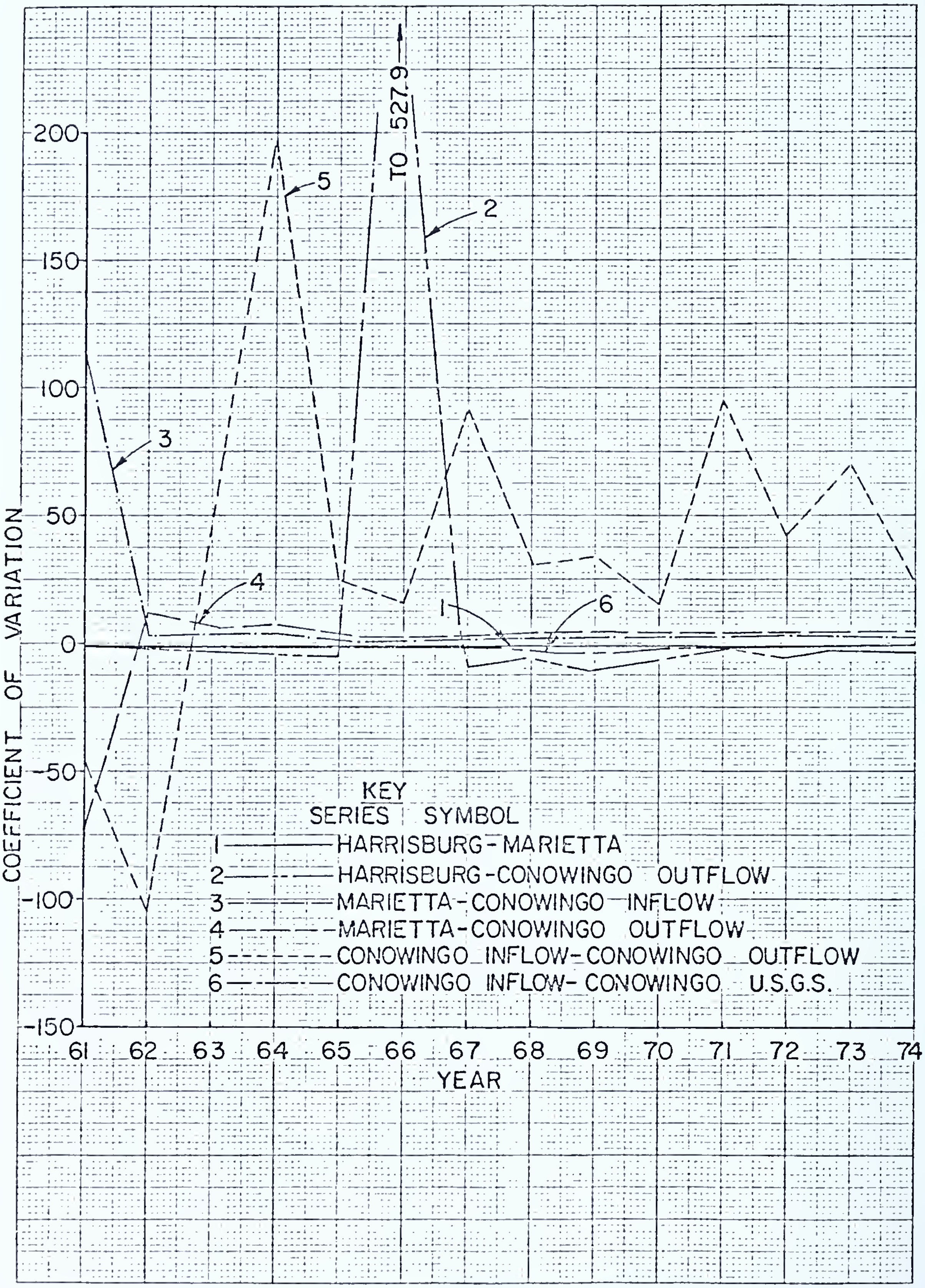

FIGURE 12
COEFFICIENT OF VARIATION OF DIFFERENCES
BETWEEN DAILY FLOW VALUES, MAR. 1 THRU OCT. 31,
EACH YEAR SHOWN

The magnitude of the losses shown may not appear to be significant because they represent a small percentage of the average flow across the 8-month period. However, when expressed in terms of the long-term 7-day, 10-year low flow at Harrisburg, such losses become very large. These values are presented in Table 1. Note for example, the mean loss of flow between Marietta and Conowingo Outflow for the 8-month period in 1964 is 749 cfs which is almost 30% of the long-term 7-day, 10-year low flow at Harrisburg.

The argument assumes that the differences truly represent losses. However, it should be recognized that the losses may be due to errors in the basic data, to natural processes which would occur regardless of the presence of Conowingo and the other power dams, or to operations of the power plants themselves. To resolve this issue considerably more work including collection of additional data and detailed examination of power generation, pond elevation and outflow values for all the power plants considered as one system is recommended.

C. Discussion of Statistical Analysis Results

The statistical analysis has been based largely on monthly means, coefficients of variation and cross correlation coefficients at lag zero. While additional information was computed it was found to be less informative than the monthly values and so has not been included in the discussion.

The monthly means appear to be generally consistent in the downstream direction with some variations which indicate possible problems. Most particularly the inconsistency between Marietta and Conowingo Inflow and the difference between Conowingo Outflow and Conowingo USGS needs further study.

The Harrisburg and Marietta flows appear to be consistent considering the monthly mean flows, the lag zero cross correlation coefficients, and the differences between the two stations. The Harrisburg and Marietta flows each appear to be consistent with the Conowingo Inflows based on the monthly means and the lag zero cross correlation coefficients but the consistency of Conowingo Inflow is not as definite as for the case of Harrisburg and Marietta. In particular there is an apparent loss of water between Marietta and Conowingo Inflow, as shown by the difference calculations. It also appears that the monthly means are reasonably consistent for Conowingo Outflow compared with other stations, but the variability of the daily flows and the correlation of daily flows depends on the flow conditions. Specifically, the variability and correlation of flows for the Conowingo Outflow is comparable or consistent during high flow periods, but not during low flow periods. We believe that this is caused by the operation of Conowingo.

TABLE 1

RATIO OF MARIETTA-CONOWINGO OUTFLOW DIFFERENCE TO
LONG TERM HARRISBURG 7-DAY, 10-YEAR LOW FLOW

YEAR	MARIETTA-CONOWINGO OUTFLOW (CFS)	RATIO TO HARRISBURG Q7-10 PERCENT
1961	-45	-1.81
1962	322	12.98
1963	584	23.55
1964	749	30.20
1965	1259	50.77
1966	1915	77.22
1967	1992	80.32
1968	1271	51.25
1969	1436	57.90
1970	2224	89.68
1971	1319	53.19
1972	3870	156.05
1973	1518	61.21
1974	1720	69.35

It appears that the Conowingo Outflow and Conowingo USGS station are not consistent in terms of monthly mean flows but are consistent in terms of lag zero cross correlation. The consistency of those two stations with respect to variability of flow is somewhat questionable.

The consistency of monthly means, standard deviations, and lag zero cross correlations during high flow months confirms the hypothesis that there is little or no effect of the power dams on flows during high flow months. The basic consistency is maintained for monthly means during low flow months indicating that the effects of the power dams are averaged out over the monthly period. Conversely the coefficient of variation for Conowingo Outflow during low flow periods compared with other locations shows greater variability of the Conowingo releases during low flow periods which then indicates a regulation effect. Also the lag zero cross-correlation coefficients show a regulation effect during low flow months.

The inconsistencies in monthly mean flow in the downstream direction and the sign and magnitude of the differences in daily flows in the downstream direction require further examination.

There are five possible explanations for the apparent loss of flow between Marietta and Conowingo Outflow.

1. Evaporative losses from the Safe Harbor, Muddy Run, Holtwood and Conowingo pools.

2. Difference in procedures used for computing discharges.

3. Underestimation of changes in amount of storage for the above four impoundments.

4. Underestimation of the Conowingo releases.

5. Overestimation of Marietta discharges.

The Conowingo Outflow data, according to Philadelphia Electric Company, is computed from the hydraulic equivalent of the amount of power generated, the spillway discharge and the amount of leakage around the spillway gates and the penstock gates. The Conowingo Inflow data is computed by adding or subtracting changes in pondage for the above four impoundments, and then adding Peach Bottom consumptive loss and Baltimore and Chester withdrawals.

The only factors in the computation of the Conowingo Inflow data which are actual losses are the evaporative loss from the pools, the Peach Bottom consumptive loss and the Baltimore

and Chester withdrawals. The Baltimore withdrawal historically has been zero with the exception of a few days and can be ignored for the present purpose. Chester data and preliminary computations show the following:

Chester Withdrawal 30 mgd		45 cfs
Evaporative Losses Peach Bottom (max. expected with towers in place)		55 cfs
Conowingo Evaporative Loss		50 cfs
	TOTAL	150 cfs

Assuming that Muddy Run, Safe Harbor and Holtwood each have the same evaporative loss as Conowingo, about 300 cfs total loss or less than one-third of the average loss between Marietta and Conowingo Outflow can be accounted for.

Underestimation of changes in storage could result in systematic underestimation of Conowingo Inflow if such systematic error occurred only when natural flows are decreasing. It would be necessary to postulate a systematic underestimation of changes in storage during decreasing natural flows, and a corresponding overestimation during increasing natural flows to explain the observed data.

Differences in procedures for computing discharges between Marietta and Conowingo unquestionably exist and would seem the most likely explanation for the apparent losses. However, if that were the explanation, the Conowingo Inflow should always be greater than or equal to Conowingo Outflow except for changes in pondage. Changes in pondage should average out to zero unless there is a systematic error in the storage estimates as discussed in the previous paragraph. Figures 10 and 11 show that the Conowingo Outflow is on average less than the inflow. Therefore, considering all the data, it doesn't appear that differences in procedures would account for the loss in flow.

In the course of collecting data for a study of instream flow needs downstream from Conowingo, discharge measurements were made by USGS using current meters and standard techniques. Arrangements were made with Philadelphia Electric Company to release specified flows. A comparison of the flows being released with the flows actually measured is as follows:

Nominal Release Based On Gate Rating (cfs)	USGS Current Meter Measurements (cfs)	Turbines Used
2500	3330	2
5000	6710	2
10000	12400	2, 5
15000	17600	2, 5, 6

Notice that in all cases, the current meter measurement is considerably greater than the nominal release based on gate rating curves. It would appear that the Conowingo outflows are underestimated by the procedures being used by the power company. That result in consistent with curves E and F in Figure 10. Curve F shows that the Conowingo outflows measured by USGS are greater than the inflows to Conowingo based on Philadelphia Electric Company data. Curve E in Figure 10 shows relatively small differences between Conowingo Inflow and Conowingo Outflow, so that the differences between Conowingo Outflow and Conowingo USGS would be similar to Curve F. Thus, the underestimation of outflows by Philadelphia Electric Company appears to explain the inconsistency between Conowingo Outflow and Conowingo USGS and may explain the anomaly between Marietta and Conowingo Inflow.

It is possible that a combination of the above causes will explain the computed loss but that doesn't appear likely. The possibility of overestimation of Marietta discharges will be studied in more detail in connection with the York Haven project review.

The major results of this study of the effects of Conowingo operation on historical flows are summarized by the flow duration curves shown in Figures 13 through 17. The flow duration curve gives the percentage of time that a given flow is exceeded at the given location. Notice that the Harrisburg, Marietta and Conowingo Inflow curves are essentially parallel to each other and the only inconsistency is in the relative position of Conowingo Inflow and Marietta curves. The Conowingo Outflow curve is essentially coincident with the Conowingo Inflow curve, for discharges greater than about 5,000 cfs. For discharges less than 5,000 cfs, the Conowingo Outflow curve is much steeper than the Conowingo Inflow curve. The Outflow curve goes to zero while the Inflow curve ends at about 1,700 cfs. The zero outflow condition appears to occur about 3% of the time. It is interesting that the break in the outflow curve comes at about 5,000 cfs, because that is the flow rate for one generating unit operating at the most efficient gate setting. Discharges less than 5,000 cfs occur about 17% of the time during the 8-month period for the 14 years studied which then suggests that

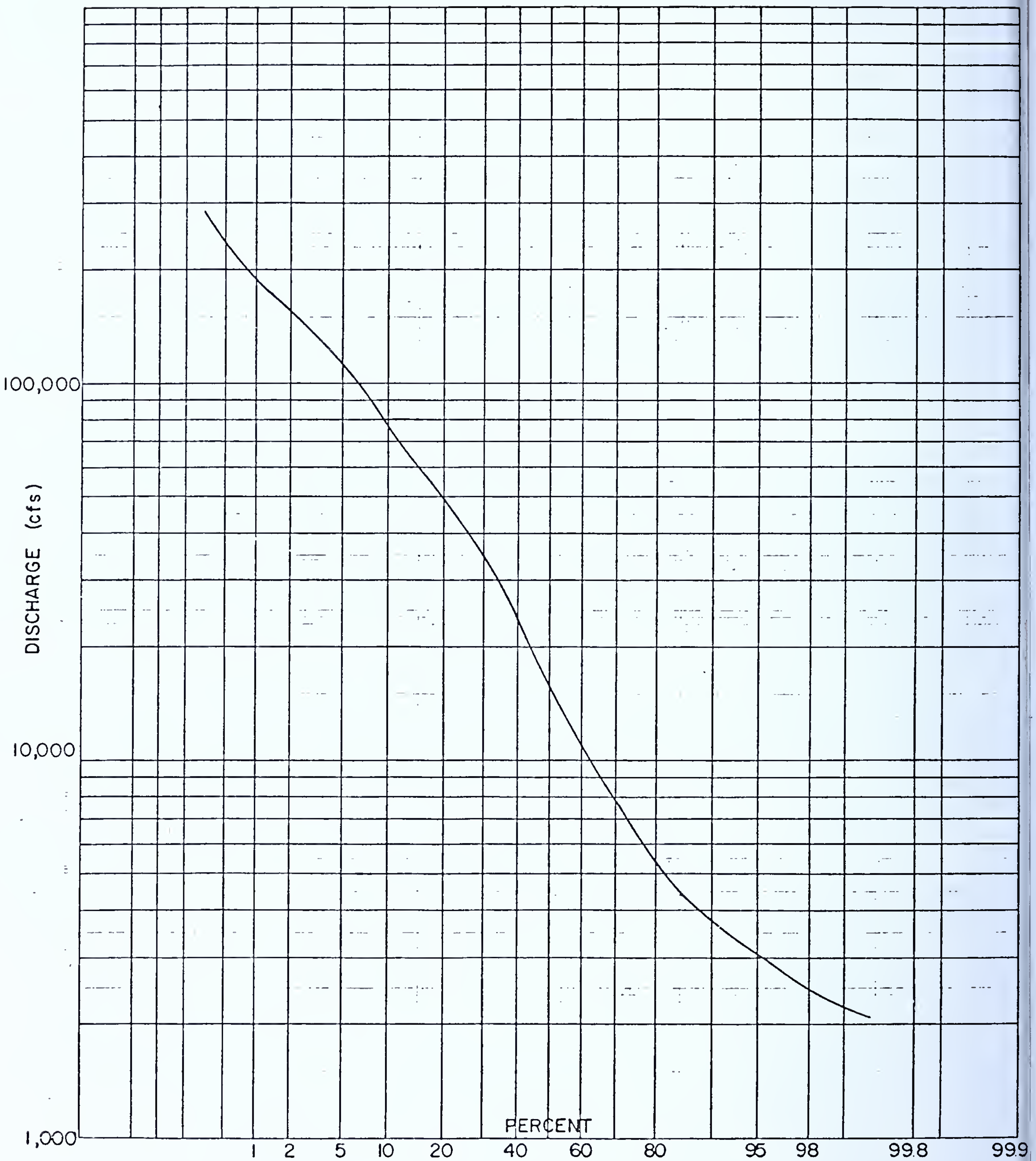

FIGURE 13
FLOW DURATION CURVE
SUSQUEHANNA RIVER AT HARRISBURG, PA.
MONTHS OF MARCH THRU OCT. INCLUSIVE
1961 - 1974

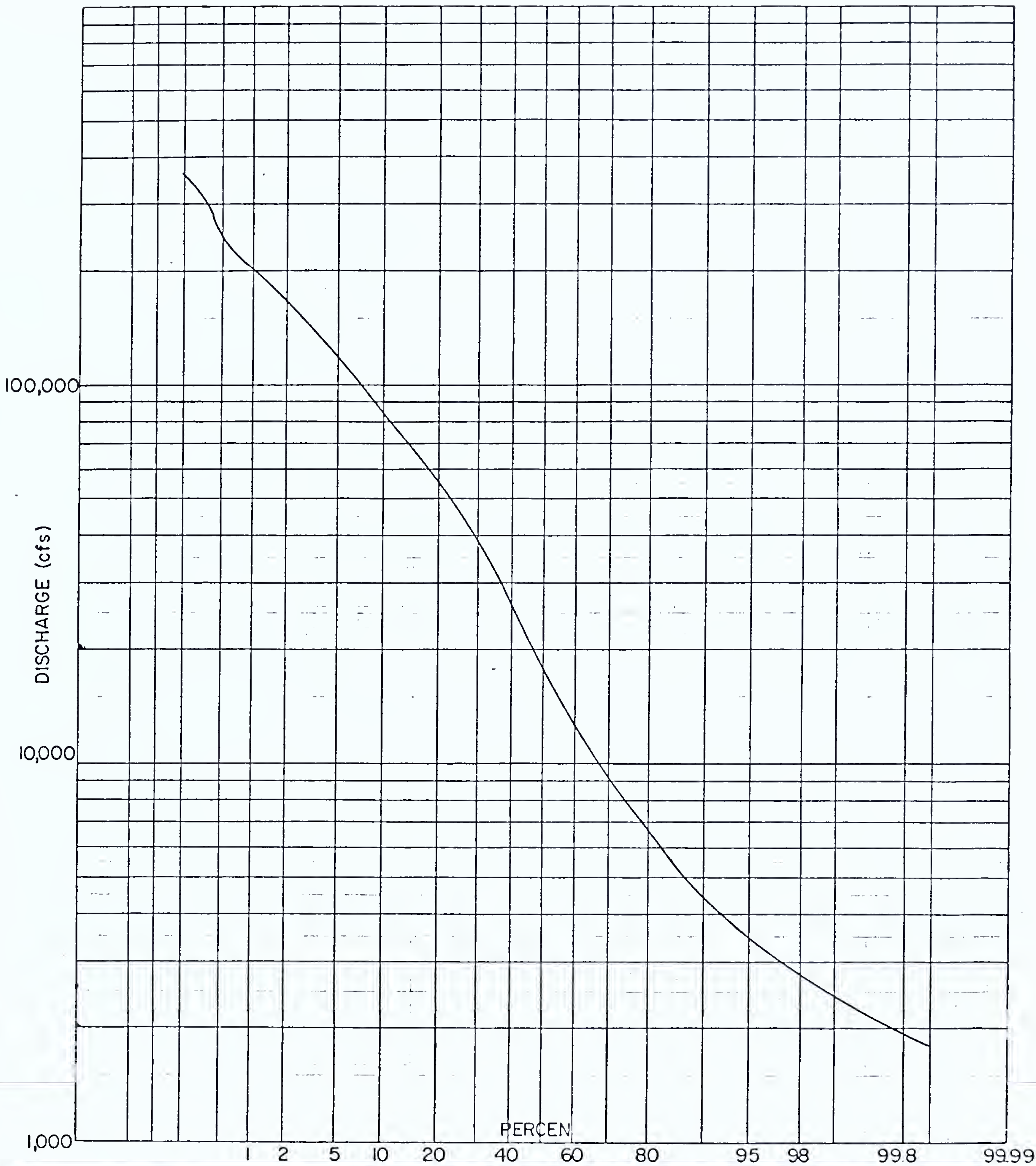

FIGURE 14
FLOW DURATION CURVE
SUSQUEHANNA RIVER AT MARIETTA, PA.
1961 - 1974
MONTHS OF MARCH THRU OCT. INCLUSIVE

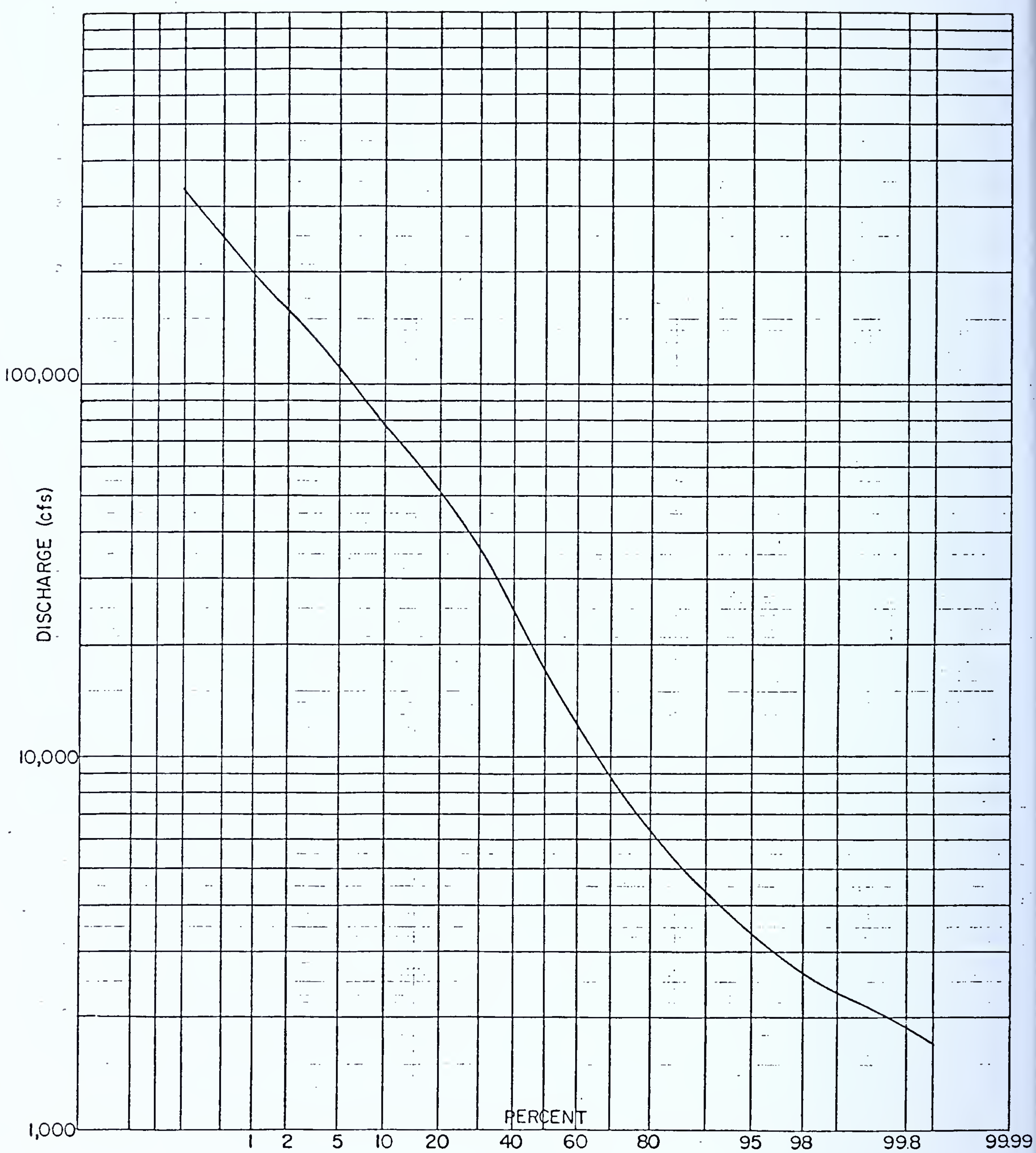

FIGURE 15
FLOW DURATION CURVE
SUSQUEHANNA RIVER INFLOW TO CONOWINGO DAM
1961 - 1974
MONTHS OF MARCH THRU OCTOBER, INCLUSIVE

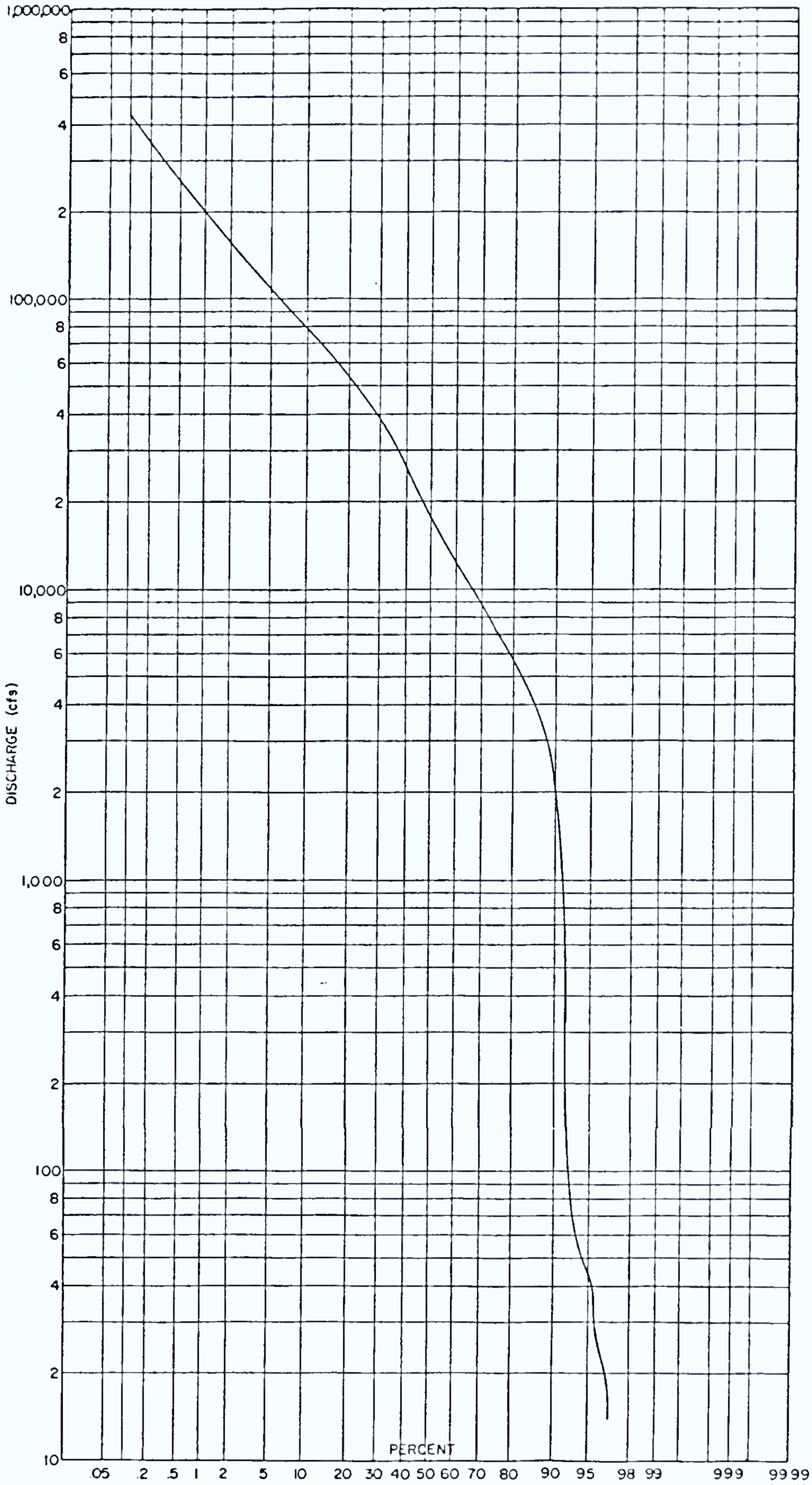

FIGURE 16
FLOW DURATION CURVE
SUSQUEHANNA RIVER OUTFLOW FROM CONOWINGO DAM
1961 - 1974
MONTHS OF MARCH THRU OCTOBER, INCLUSIVE

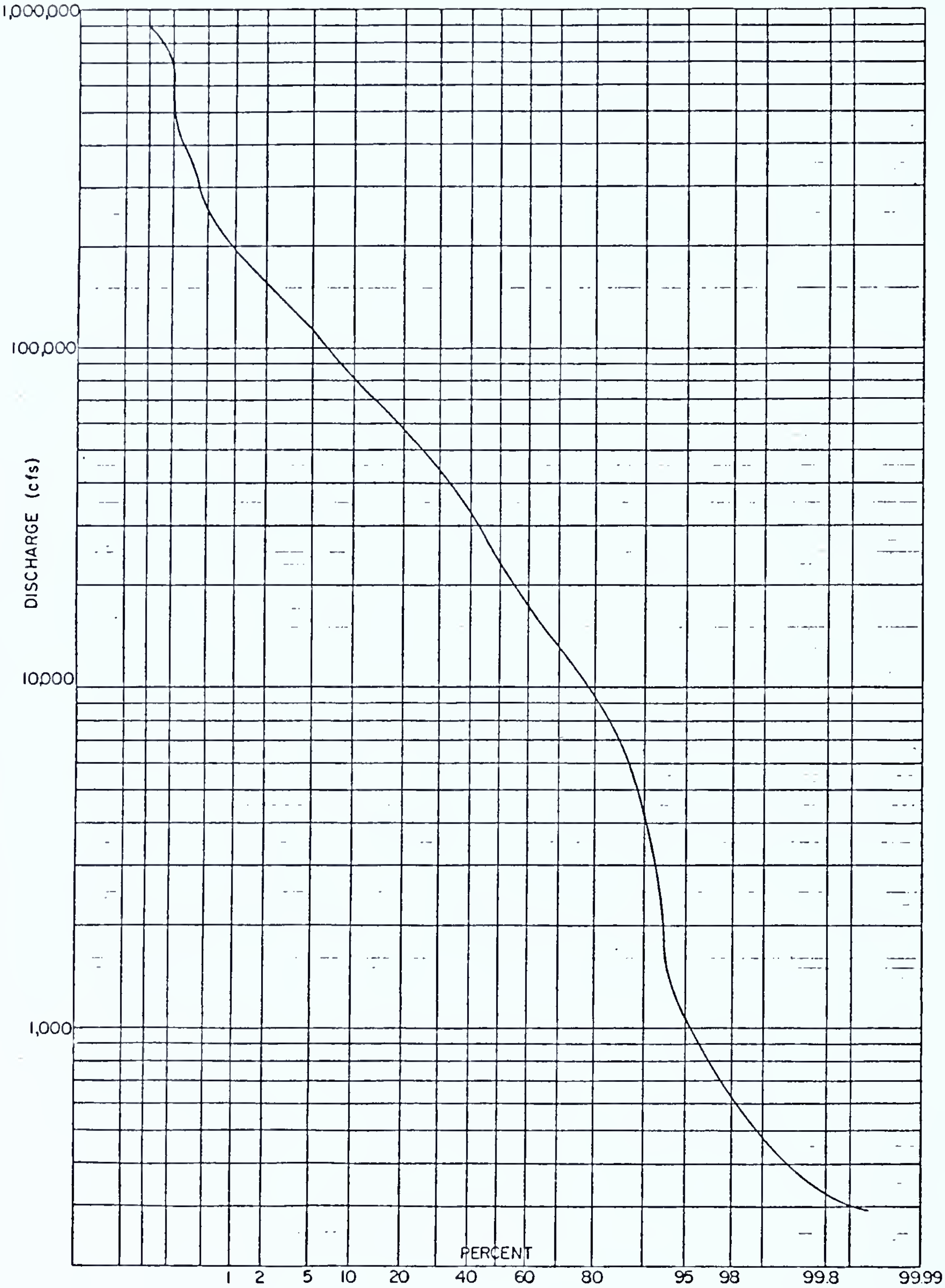

FIGURE 17
FLOW DURATION CURVE
SUSQUEHANNA RIVER AT CONOWINGO, MD.
1968 - 1974
MONTHS OF MARCH THRU OCT. INCLUSIVE

Conowingo operations affect flows about 17% of the time for the study period. By way of comparison, during the entire period of record 1892-1976, flows at the Harrisburg gage are less than 5,000 cfs about 9% of the time. Thus, over the long term Conowingo can be expected to affect flows occurring approximately 9% of the time.

The low flow frequency curves for various durations are shown in Figures 18 through 22, for Harrisburg, Marietta, Conowingo Inflow and Conowingo Outflow for the 8-month period in the years 1961-74. No low flow frequency curve is shown for the Conowingo USGS station because the 7-year sample is too short to warrant computations of low flow frequency curves. Also, no curve is shown for the Conowingo Outflow for the 1-day duration. The reason is that the array of 1-day low flow values for this station included three values of 25 cfs and eleven values of zero cfs. Therefore, a low flow frequency analysis could not be made.

Because of the short record lengths, these curves should not be extrapolated beyond the 5% chance of nonexceedance (20-year low flow).

The curves appear to be reasonably self-explanatory. Notice that for a duration of seven days or less, the Conowingo Outflow is practically always below the corresponding curve for the other stations, again demonstrating the effect of Conowingo operation on low flows. Notice that for the 7-day 5% chance of nonexceedance event, the Conowingo Outflow is about 400 cfs as compared with Harrisburg, Marietta and Conowingo Inflow values of about 1,800 cfs. This shows that based on the sample, which is admittedly small, once every 20 years the Conowingo operation will reduce the 7-day duration low flow by about 80%. One-day duration low flows are reduced to near zero almost every year.

IV. SIMULATION OF EFFECTS OF FUTURE WITHDRAWALS AND OPERATING PROCEDURES

A. Preliminary Studies

A computer program was written to simulate the effects of future withdrawals and changes in operating procedures. The program takes daily inflows to Conowingo, subtracts an appropriate withdrawal, which includes consumptive losses for Peach Bottom, constant withdrawals for Chester and Baltimore water supply, and an evaporative loss from the pool. The following withdrawals were assumed:

Chester - Constant withdrawal of 30 mgd (47 cfs).

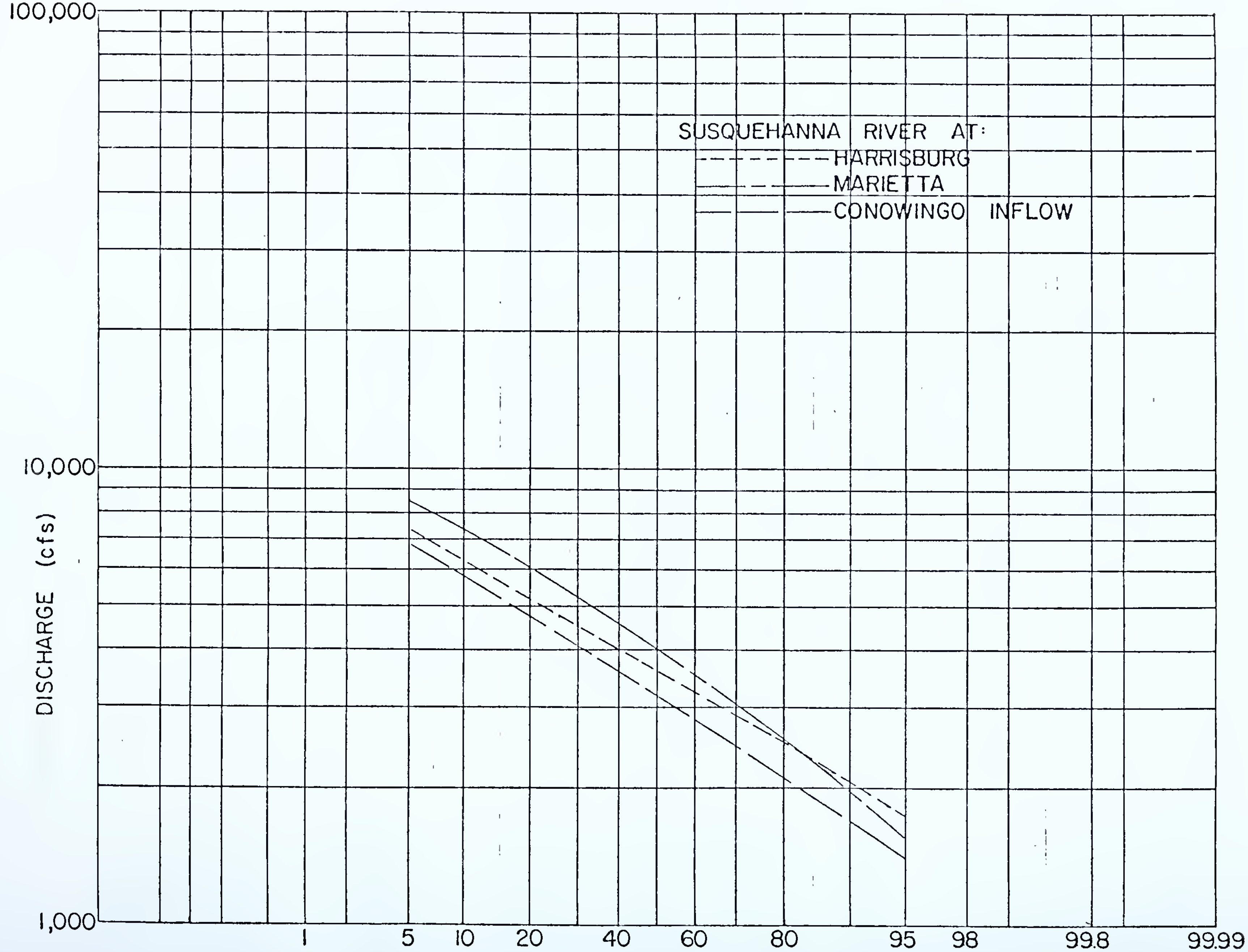

FIGURE 18
1 DAY LOW FLOW 1961-1974
MONTHS OF MARCH THRU OCTOBER INCLUSIVE

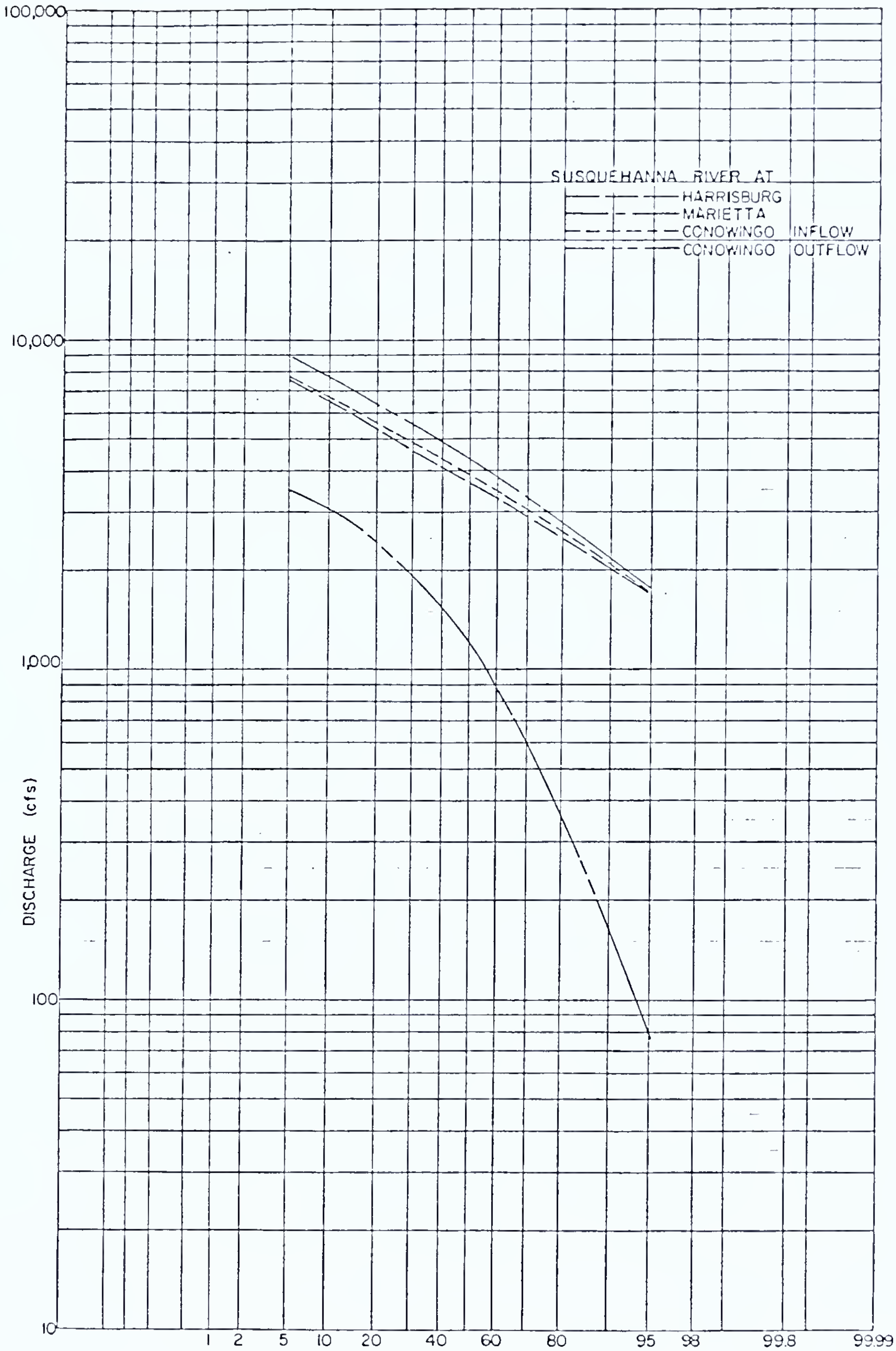

FIGURE 19
3 DAY LOW FLOW 1961-1974
MONTHS OF MARCH THRU OCTOBER INCLUSIVE

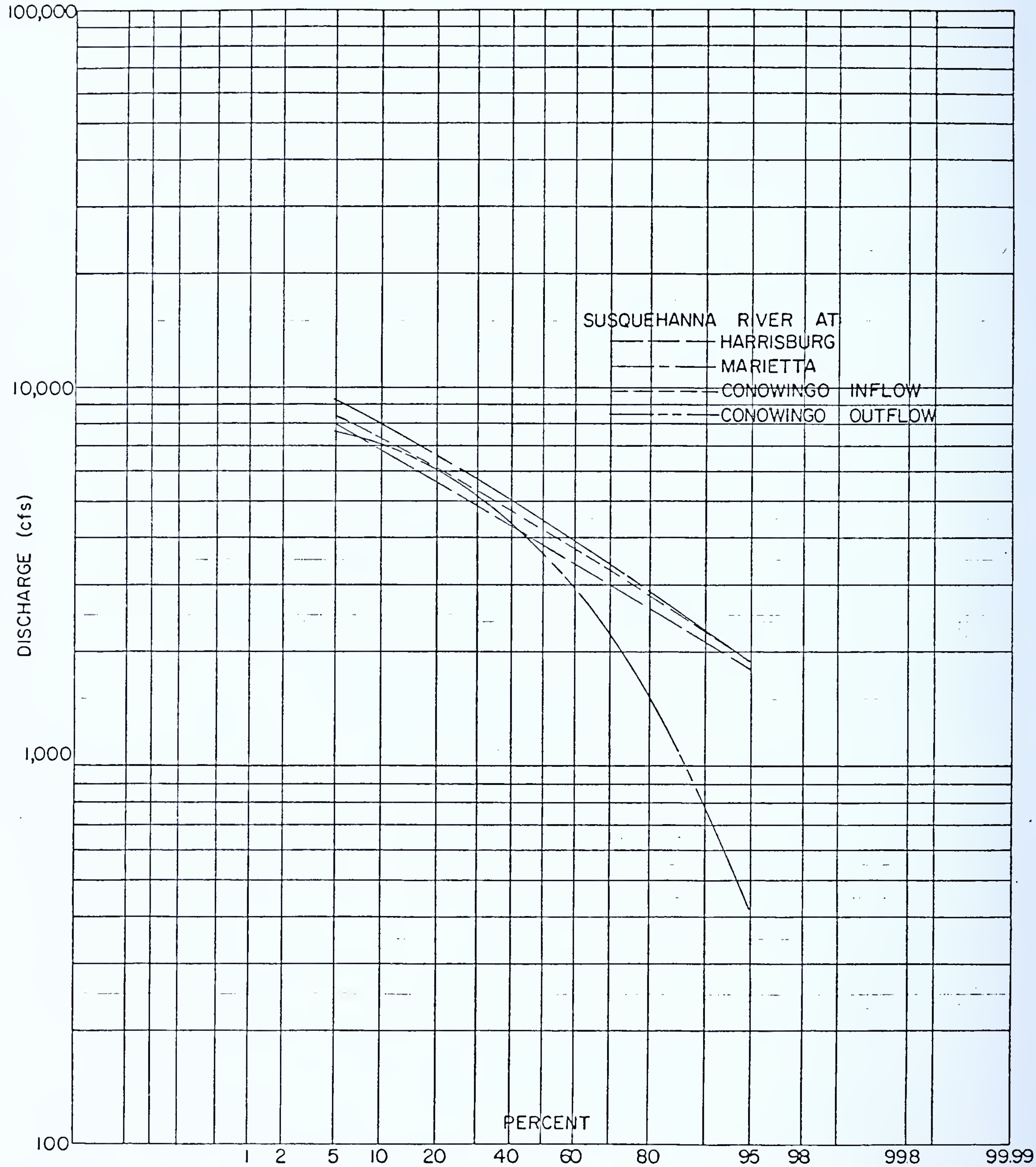

FIGURE 20
7 DAY LOW FLOW 1961-1974
MONTHS OF MARCH THRU OCTOBER INCLUSIVE

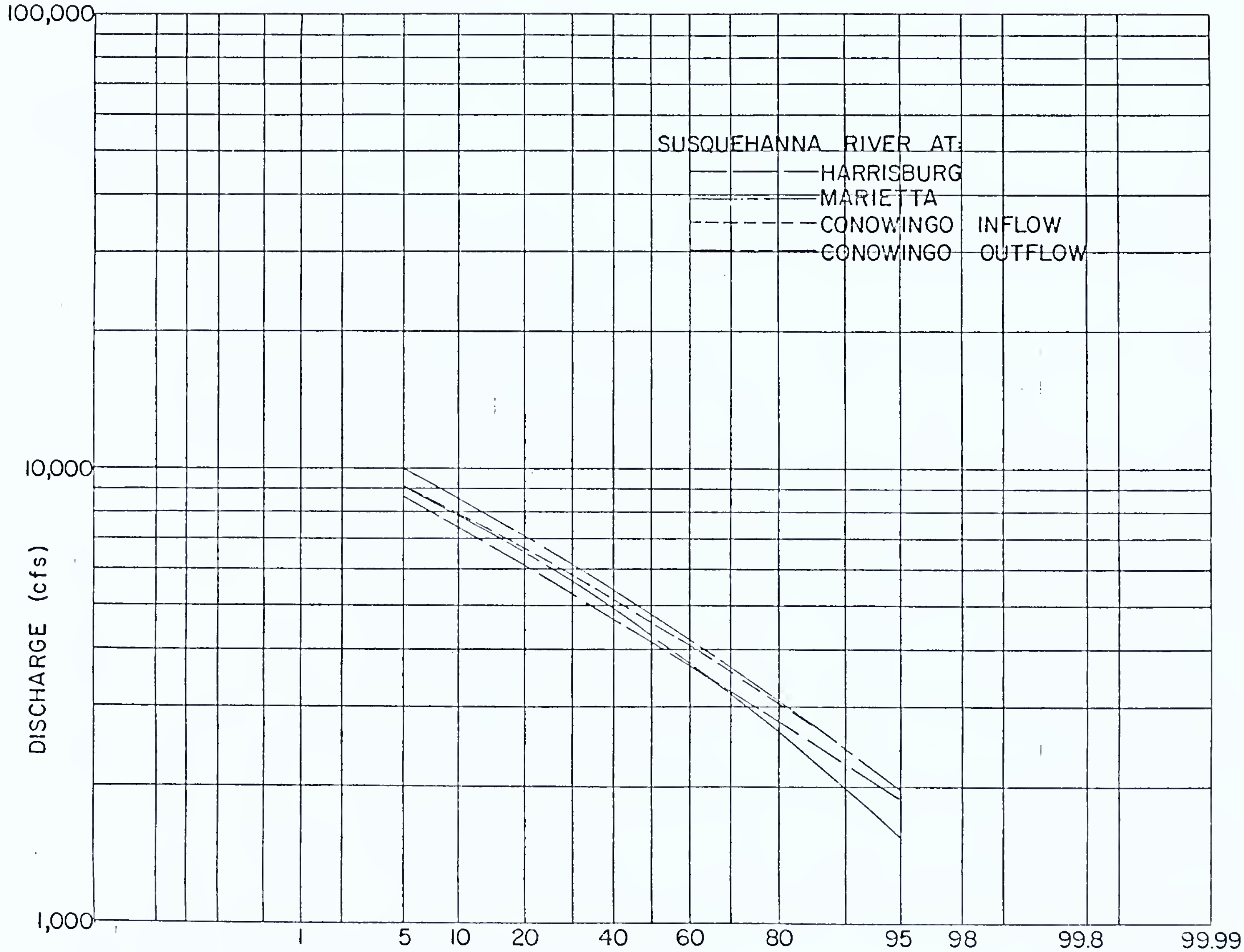

FIGURE 21
14 DAY LOW FLOW 1961-1974
MONTHS OF MARCH THRU OCTOBER INCLUSIVE

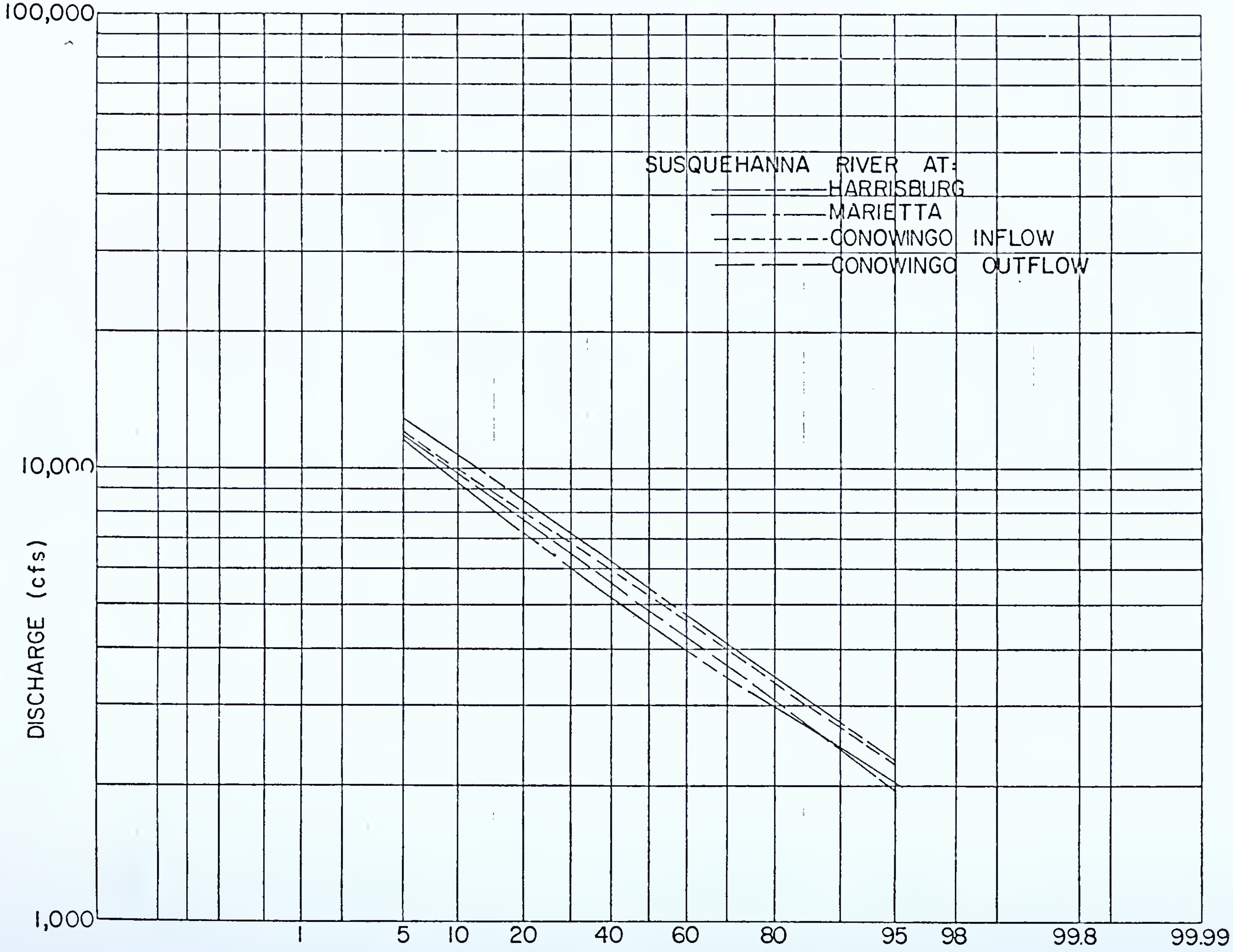

FIGURE 22
30 DAY LOW FLOW 1961-1974
MONTHS OF MARCH THRU OCTOBER INCLUSIVE

Baltimore - Constant withdrawal of 250 mgd (389 cfs).

Peach Bottom - Constant loss of 55 cfs.

Evaporation From Pool - 50 cfs for the period May 1st through October 31st of each year; zero for balance of year.

The net inflow is then the observed inflow minus either 541 cfs for the period May 1st through October 31st of each year or 491 cfs for the remainder of the year. The Marietta data was assumed to adequately represent observed inflow to the Conowingo Pool. This net inflow was then routed through the storage assuming full pool (elevation 109.2 ft. msl) on March 1st of each year. The elevation-storage curve was furnished by Philadelphia Electric Company.

The daily outflow was determined from the net inflow by using ratios of outflow to inflow at certain flow levels as determined by Armbruster (4). For inflows of 2,500 cfs, 5,000 cfs and 15,000 cfs the ratios were obtained by determining the total daily generation using typical operating curves presented in the Conowingo relicensing application (5). For other discharges, the ratios were determined by trial and error in the development of the model. Marietta and Conowingo USGS data were used in that determination. The operating schedule used in this part of the study is shown in Figure 23.

The normal pool elevation for Conowingo is 109.2 ft. msl (108.5 ft. Conowingo datum). The power company attempts to maintain the pool elevation at or above 107.2 ft. msl on weekends during the recreation season in order to permit access to the pool. Also the operating license for Peach Bottom Atomic Power Plant requires that plant to be shut down whenever the Conowingo pool elevation falls below 99.2 ft. msl. These elevations represent constraints imposed on the Conowingo operation. These constraints were modeled by checking the outflow determined from the operating schedule as follows:

1. If outflow is less than a specified minimum release, increase the outflow to equal the specified release, and recompute the pool elevation.

2. If pool elevation is greater than 109.2 ft. msl assume sufficient water is spilled to bring the pool elevation down to 109.2 ft. msl.

3. If the pool elevation is less than 107.2 ft. msl on weekends during the period May 1st through September 30th compute a deficiency of storage below that elevation.

4. If the pool elevation is less than 99.2 ft. msl at any time compute the deficiency of storage below that elevation.

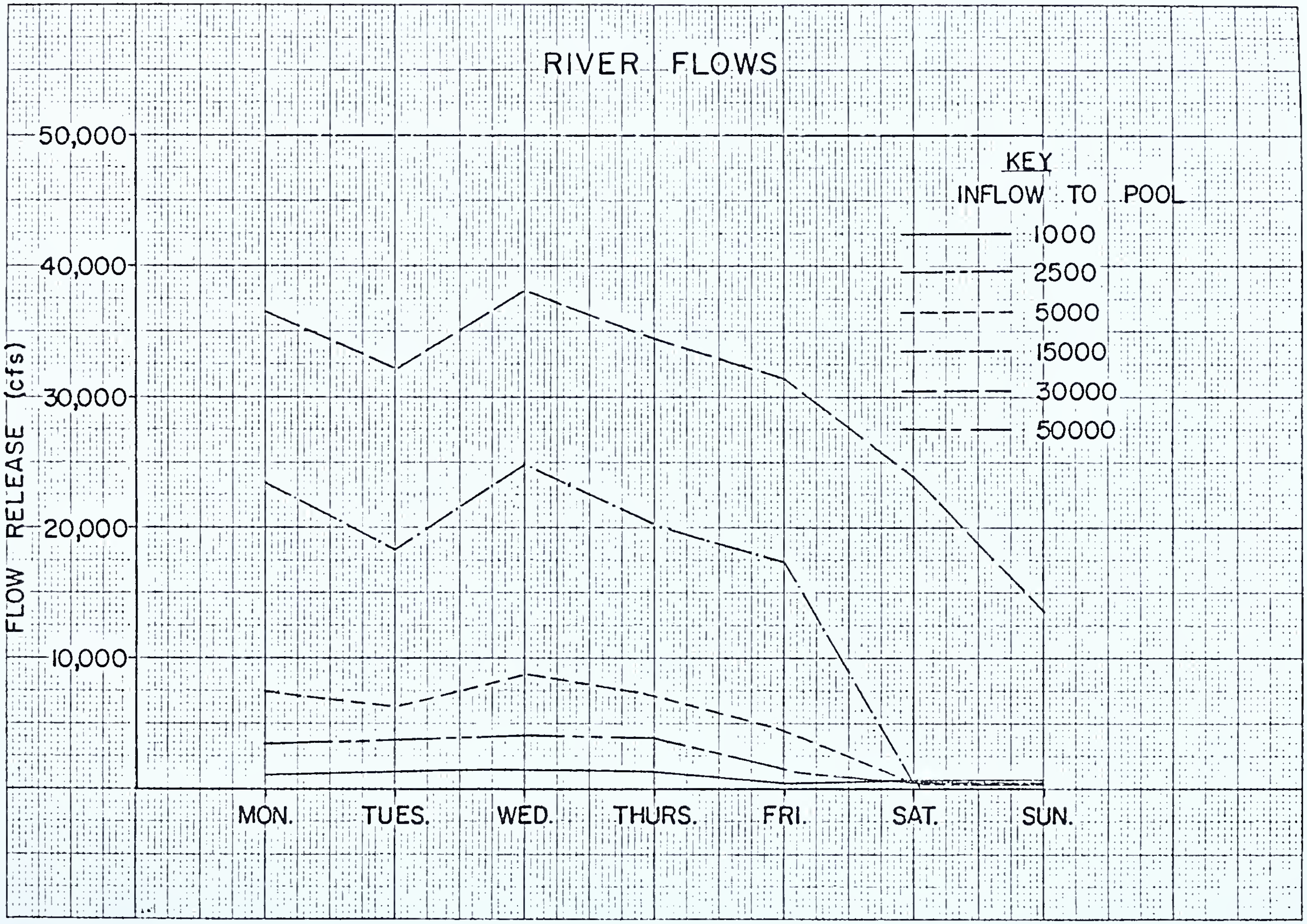

FIGURE 23
CONOWINGO POWER GENERATION OPERATING SCHEDULE

Three different release requirements were considered:

1. Minimum release of 5,188 cfs during the period March 1st to July 1st, no minimum release for remainder of the year. This basically represents the current release required by the State of Maryland.

2. Minimum release of 15,188 cfs during the period March 1st through June 1st, 5,000 cfs for remainder of the year.

3. Minimum release of 5,188 cfs for period March 1st to July 1st and 5,000 cfs for remainder of year.

These will be noted herein as release requirements 1, 2 and 3.

For each of these three cases, the resulting outflow was computed for each day for the period March 1st through October 31st for each year between 1961 and 1974. Low flow frequency and flow duration curves were also computed. The minimum pool elevation for each year and each release requirement is shown in Table 2. The number of days with deficiencies of storage and the mean deficiency of storage below elevation 107.2 for each year and release requirement is shown in Table 3 and the corresponding values for deficiencies below elevation 99.2 are shown in Table 4. The distribution of such deficiencies during the year are shown in Tables 5 through 10.

These computations show that for release requirement No. 1 with the future withdrawals superimposed, the pool cannot be maintained above elevation 107.2 ft. msl for all weekends even during the relatively high flow years. In fact, with the current operating schedule it is not possible to maintain pool elevation above 99.2 ft. msl with release requirement No. 1. There is only a slight change in the number of deficits below elevation 107.2 occurring on weekends between different release requirements. There is a relatively large change in minimum pool elevations for release requirements No. 2 and No. 3 compared to release requirement No. 1 in certain years, and a corresponding increase in the mean deficits in certain years. For all three release requirements the deficits below elevation 107.2 ft. msl on weekends are consistently and rather uniformly distributed across the months of May through September. The program does not compute deficiencies below elevation 107.2 during March, April or October. The number of deficiencies appears to be uniformly distributed between years regardless of operating scheme.

The deficiencies below elevation 99.2 ft. msl occur in all months but are most prominent during the months of June through October. There are relatively large increases in the

TABLE 2

MINIMUM POOL ELEVATION
FT. ABOVE MSL

Year	Release Requirement No. 1	Release Requirement No. 2	Release Requirement No. 3
1961	101.8	87.0	87.0
1962	86.8	86.7	86.7
1963	98.5	86.7	86.7
1964	90.1	86.6	86.6
1965	86.7	86.7	86.7
1966	93.6	86.7	86.7
1967	89.7	86.7	86.7
1968	97.9	86.6	86.6
1969	95.0	86.7	86.7
1970	93.7	86.7	86.7
1971	88.1	86.7	86.7
1972	101.7	86.6	86.6
1973	92.4	89.2	89.2
1974	96.0	86.7	86.7

TABLE 3

NUMBER OF DAYS AND MEAN MAGNITUDE OF DEFICITS BELOW ELEVATION 107.2 MSL

Year	Release Requirement No. 1		Release Requirement No. 2		Release Requirement No. 3	
	No.of Days	Mean Def. cfs-days	No.of Days	Mean Def. cfs-days	No.of Days	Mean Def. cfs-days
1961	20	6044	30	46112	30	46352
1962	41	61457	42	727381	41	555383
1963	36	21862	44	507509	36	534357
1964	44	90819	44	390316	44	253069
1965	44	81234	44	716531	44	566688
1966	41	32496	43	140069	41	121519
1967	41	26952	42	464163	41	449566
1968	40	15441	44	951484	40	101208
1969	41	20024	44	949439	41	290115
1970	39	20577	39	59766	39	60572
1971	40	30127	41	79218	40	76081
1972	32	6977	36	152025	36	152025
1973	44	33051	44	82877	44	82877
1974	37	14425	38	53037	38	53508

TABLE 4

NUMBER OF DAYS AND MEAN MAGNITUDE OF DEFICITS BELOW ELEVATION 99.2 MSL

Year	Release Requirement No. 1		Release Requirement No. 2		Release Requirement No. 3	
	No. of Days	Mean Def. cfs-days	No.of Days	Mean Def. cfs-days	No.of Days	Mean Def. cfs-days
1961	0	0	93	75052	93	75171
1962	150	50617	164	793007	150	688491
1963	17	1152	131	777465	118	805931
1964	148	95792	159	537331	148	432815
1965	196	115404	201	693114	196	578563
1966	133	12082	166	211709	133	183431
1967	107	12855	129	782923	125	784872
1968	5	2472	235	730425	109	379612
1969	34	4893	235	926428	132	587439
1970	62	6090	116	104262	116	105252
1971	124	11448	136	113216	133	105002
1972	0	0	72	657643	72	657643
1973	127	15450	134	104018	134	104018
1974	27	5829	101	240162	102	255770

TABLE 5

DISTRIBUTION OF NUMBER OF
DEFICITS BELOW ELEVATION 107.2 MSL
OCCURRING ON WEEKENDS
RELEASE REQUIREMENT NO. 1

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	4	5	4	7	0	20
1962	0	0	5	9	9	8	10	0	41
1963	0	0	3	7	8	9	9	0	36
1964	0	0	10	8	8	10	8	0	44
1965	0	0	10	8	9	9	8	0	44
1966	0	0	8	7	10	8	8	0	41
1967	0	0	7	7	10	8	9	0	41
1968	0	0	6	8	8	9	9	0	40
1969	0	0	6	9	8	10	8	0	41
1970	0	0	6	7	8	10	8	0	39
1971	0	0	7	7	9	9	8	0	40
1972	0	0	6	7	6	4	9	0	32
1973	0	0	8	9	9	8	10	0	44
1974	0	0	3	9	7	9	9	0	37
TOTAL	0	0	85	106	114	115	120	0	540

TABLE 6

DISTRIBUTION OF NUMBER OF
DEFICITS BELOW ELEVATION 99.2 MSL
RELEASE REQUIREMENT NO. 1

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	0	0	0	0	0	0
1962	0	0	1	26	31	31	30	31	150
1963	0	0	0	0	7	1	4	5	17
1964	0	0	0	25	31	31	30	31	148
1965	0	24	19	30	31	31	30	31	196
1966	0	0	0	10	31	31	30	31	133
1967	0	0	0	4	16	28	29	30	107
1968	0	0	0	0	3	0	0	2	5
1969	2	0	0	9	15	8	0	0	34
1970	0	0	0	1	16	13	13	19	62
1971	0	0	0	10	31	26	27	30	124
1972	0	0	0	0	0	0	0	0	0
1973	0	0	0	12	29	29	27	30	127
1974	0	0	0	6	0	0	7	14	27
TOTAL	2	24[1]	20	133	241	229	227	254	1130

TABLE 7

DISTRIBUTION OF NUMBER
OF DEFICITS BELOW ELEVATION 107.2 MSL
OCCURRING ON WEEKENDS
RELEASE REQUIREMENT NO. 2

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	4	9	8	9	0	30
1962	0	0	6	9	9	8	10	0	42
1963	0	0	8	10	8	9	9	0	44
1964	0	0	10	8	8	10	8	0	44
1965	0	0	10	8	9	9	8	0	44
1966	0	0	9	8	10	8	8	0	43
1967	0	0	8	7	10	8	9	0	42
1968	0	0	8	10	8	9	9	0	44
1969	0	0	9	9	8	10	8	0	44
1970	0	0	6	7	8	10	8	0	39
1971	0	0	7	8	9	9	8	0	41
1972	0	0	6	7	6	8	9	0	36
1973	0	0	8	9	9	8	10	0	44
1974	0	0	3	9	8	9	9	0	38
TOTAL	0	0	98	113	119	123	122	0	575

TABLE 8

DISTRIBUTION OF NUMBER OF
DEFICITS BELOW ELEVATION 99.2 MSL
RELEASE REQUIREMENT NO. 2

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	0	6	26	30	31	93
1962	0	0	11	30	31	31	30	31	164
1963	0	0	7	2	30	31	30	31	131
1964	0	0	6	30	31	31	30	31	159
1965	0	24	24	30	31	31	30	31	201
1966	0	0	18	25	31	31	30	31	166
1967	0	0	0	7	30	31	30	31	129
1968	21	30	31	30	31	31	30	31	235
1969	21	30	31	30	31	31	30	31	235
1970	0	0	0	1	23	31	30	31	116
1971	0	0	0	13	31	31	30	31	136
1972	0	0	0	0	0	11	30	31	72
1973	0	0	0	12	30	31	30	31	134
1974	0	0	0	6	4	30	30	31	101
TOTAL	42	84	128	216	340	408	420	434	2072

TABLE 9

DISTRIBUTION OF NUMBER OF
DEFICITS BELOW ELEVATION 107.2 MSL
OCCURRING ON WEEKENDS
RELEASE REQUIREMENT NO. 3

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	4	9	8	9	0	30
1962	0	0	5	9	9	8	10	0	41
1963	0	0	3	7	8	9	9	0	36
1964	0	0	10	8	8	10	8	0	44
1965	0	0	10	8	9	9	8	0	44
1966	0	0	8	7	10	8	8	0	41
1967	0	0	7	7	10	8	9	0	41
1968	0	0	6	8	8	9	9	0	40
1969	0	0	6	9	8	10	8	0	41
1970	0	0	6	7	8	10	8	0	39
1971	0	0	7	7	9	9	8	0	40
1972	0	0	6	7	6	8	9	0	36
1973	0	0	8	9	9	8	10	0	44
1974	0	0	3	9	8	9	9	0	38
TOTAL	0	0	85	106	119	123	122	0	555

TABLE 10

DISTRIBUTION OF NUMBER OF
DEFICITS BELOW ELEVATION 99.2 MSL
RELEASE REQUIREMENT NO. 3

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	0	6	26	30	31	93
1962	0	0	1	26	31	31	30	31	150
1963	0	0	0	0	26	31	30	31	118
1964	0	0	0	25	31	31	30	31	148
1965	0	24	19	30	31	31	30	31	196
1966	0	0	0	10	31	31	30	31	133
1967	0	0	0	4	29	31	30	31	125
1968	0	0	0	0	17	31	30	31	109
1969	2	0	0	9	29	31	30	31	132
1970	0	0	0	1	23	31	30	31	116
1971	0	0	0	10	31	31	30	31	133
1972	0	0	0	0	0	11	30	31	72
1973	0	0	0	12	30	31	30	31	134
1974	0	0	0	6	5	30	30	31	102
TOTAL	2	24	20	133	320	408	420	434	1761

number of deficits in each month when changing from release requirement 1 to either release requirement 2 or 3. As expected release requirement 3 has fewer deficits in each month of the March through July period than release requirement 2. However, the pool would be below elevation 99.2 ft. msl for the entire period August through October in 12 of the 14 years for release requirements 2 or 3. Comparison of the total number of deficits for each month across years shows that during the months of March through June release requirement 3 has the same number of deficits below elevation 107.2 on weekends as release requirement 1. However, during the months of July through September release requirement 3 has the same number of deficits below elevation 107.2 on weekends as release requirement 2. The number of deficits below elevation 99.2 show similar results.

The flow duration curves for the three simulated release requirements with the future withdrawals from the Conowingo pond superimposed are shown in Figures 24 through 26. Comparison of the flow duration curve for release requirement No. 1 with the outflow based on the historic data (Figure 16) shows that the two curves are essentially identical for flows in excess of 10,000 cfs. For flows between 700 cfs and 10,000 cfs, the simulated curve is below the observed curve. This probably represents the effect of the assumed withdrawals but may also reflect differences between the assumed and the actual operating schedule. For flows less than 700 cfs, the observed curve drops rapidly toward zero flow while the simulated curve approaches an asymptote at about 300 cfs. The simulated curve was expected to remain parallel to the observed curve.

Comparison of the flow duration curve for release requirement 1 with the flow duration curve for release requirement 2 shows that the curves are essentially identical for flows in excess of 6,000 cfs. For flows less than 6,000 cfs, the flow duration curve for release requirement No. 2 approaches a horizontal asymptote at 5,000 cfs, as expected. Perhaps it should be noted that the program forces the minimum release and the resulting elevation is computed. However, the elevation-storage table used in the program has a minimum elevation of 92.0 ft. msl. Thus, computed elevations below 92.0 may be spurious, or conversely, it may not be possible to supply the required minimum release from storage whenever the elevation shown is less than 92.0. This is a flaw in the program which was not corrected because it is apparent that some other change either in the current operating schedule or the minimum release may be necessary.

Comparison of flow duration curves for release requirements 2 and 3 show that the two curves are essentially identical. Both release requirements are subject to the constraint in the simulation program noted above.

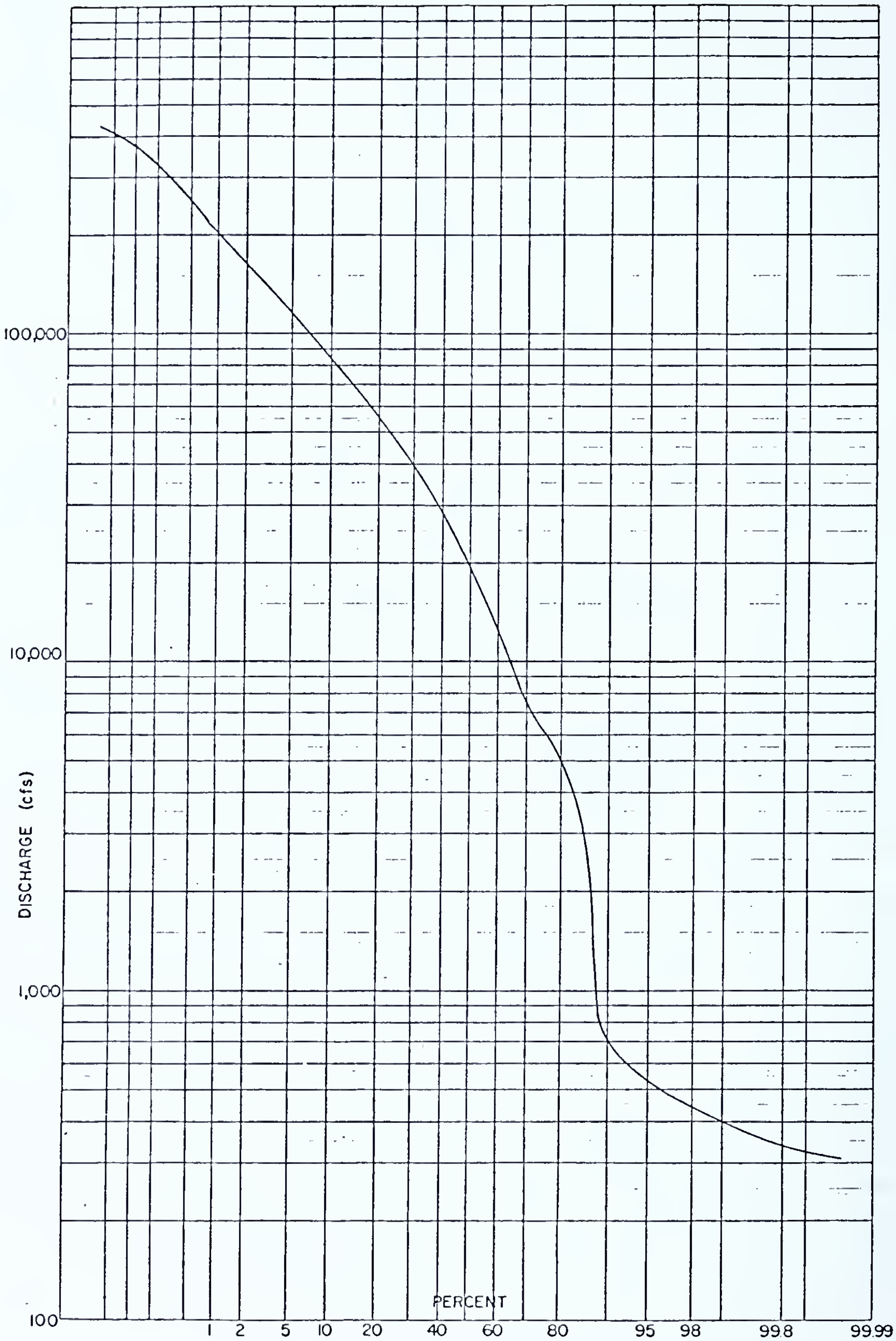

FIGURE 24
FLOW DURATION CURVE
SUSQUEHANNA RIVER OUTFLOW FROM CONOWINGO DAM
RELEASE REQUIREMENT NO. 1
1961-1974 MONTHS OF MARCH THRU OCTOBER INCLUSIVE

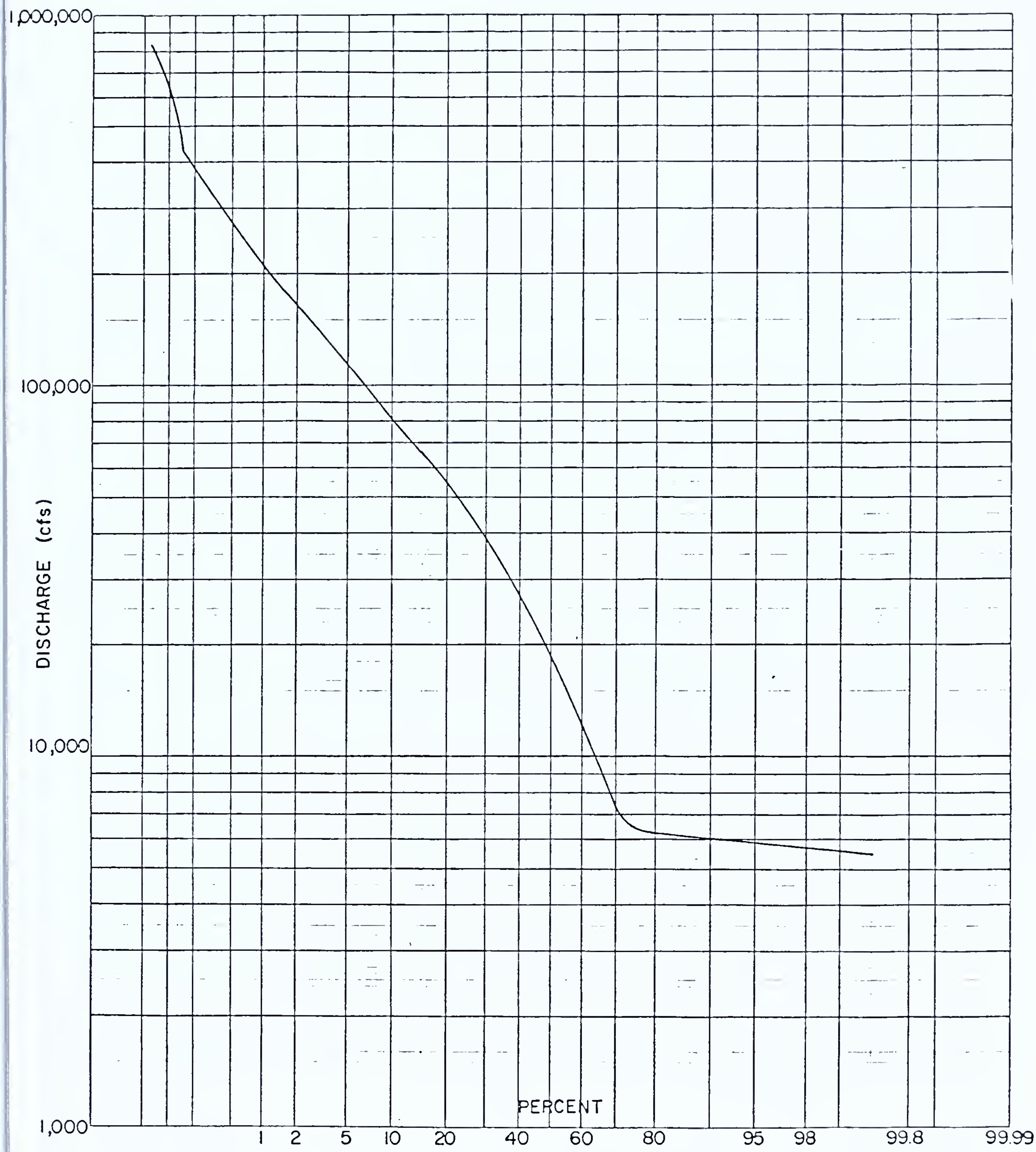

FIGURE 25
SUSQUEHANNA RIVER OUTFLOW FROM CONOWINGO DAM
RELEASE REQUIREMENT NO. 2
1961-1974 MONTHS OF MARCH THRU OCTOBER, INCLUSIVE

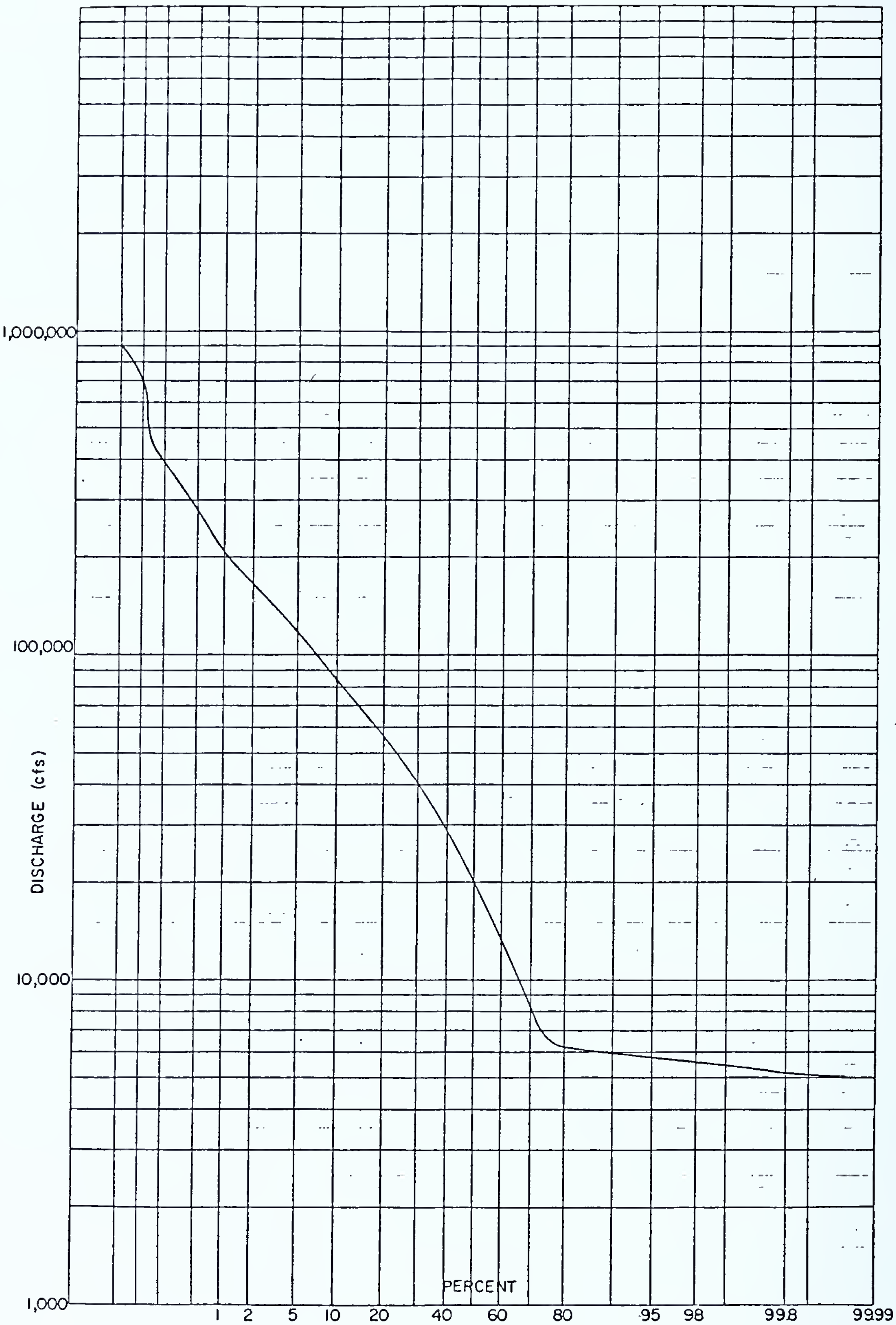

FIGURE 26
FLOW DURATION CURVE
SUSQUEHANNA RIVER OUTFLOW FROM CONOWINGO DAM
RELEASE REQUIREMENT NO. 3
1961-1974 MONTHS OF MARCH THRU OCTOBER INCLUSIVE

An effort was made to fit the low flow frequency curves for 1, 3 and 7-day durations using the log-Pearson Type III analysis. In some cases this gave unreasonable results, partly because of the short record that was simulated and partly because release requirements 2 and 3 require a minimum release of 5,000 cfs at all times. Thus, the final curves shown in Figures 27 through 29 are a combination of mathematically fitted log-Pearson Type III curves and eye-fitted straight lines. Because of the short record and the fitting techniques these curves should not be extrapolated beyond the 5% chance of nonexceedance (20-year) low flow.

The low flow frequency curve for release requirement No. 1 shows that the 1-day low flow approaches a constant value of about 300 cfs and the 3-day low flow approaches a constant value of about 600 cfs. The 7-day low flow does not approach a constant value.

The 1-day, 3-day and 7-day low flow frequency curves for release requirements 2 and 3 approach a constant value of about 5,000 cfs, as expected.

These computations show that there is insufficient water to meet the Conowingo power generation operating schedule, the proposed release requirements and the minimum pool elevation required for continued operation at Peach Bottom. There are three alternatives:

1. Establish either proposed release requirement and accept the penalty in lost generating capacity at Conowingo, Peach Bottom and possibly Muddy Run;

2. Modify the release requirements; and

3. Modify the Conowingo operation schedule.

The operating schedule (Figure 23) shows that flows in excess of inflow are released due to power generation under all flow conditions, except on weekends. The operating schedule is essentially based on the assumption that inflow occurring over a 7-day period will be released over a 5-day period. Superimposing a release requirement on the current operating schedule effectively spreads out the generation period to seven days, which causes the total outflow to exceed the total inflow during periods with inflows less than the release requirement. The result of course is that the pool is drawn down.

The results presented suggest that the operating schedule might be modified when inflow is less than some specified amount (e.g. 15,000 cfs) so that the release is spread out more or less uniformly over the 7-day period. This is roughly equivalent to operating with outflow equal to inflow during such periods.

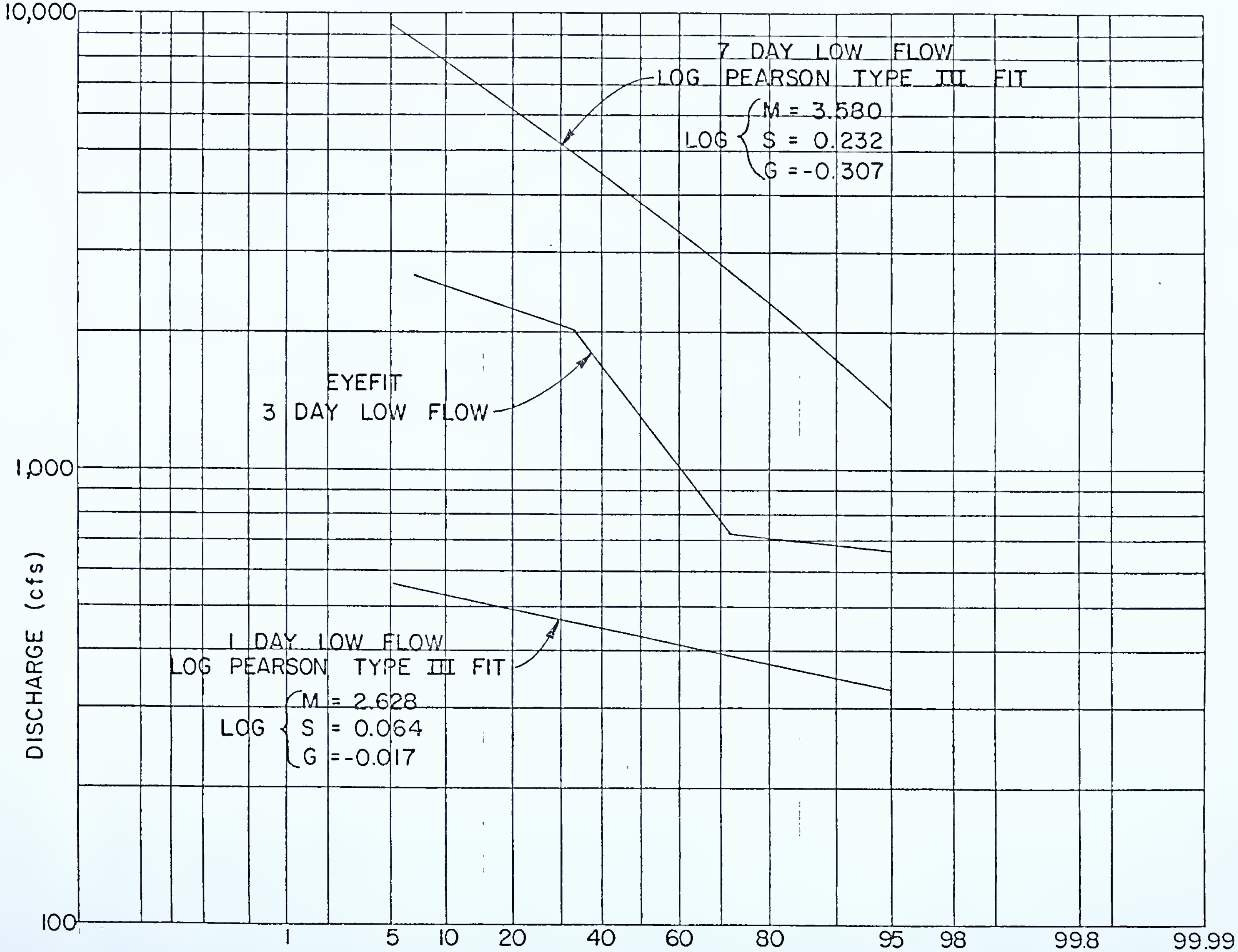

FIGURE 27
LOW FLOW FREQUENCY CURVES
SUSQUEHANNA RIVER AT CONOWINGO OUTFLOW
SIMULATED RELEASE REQUIREMENT NO. 1

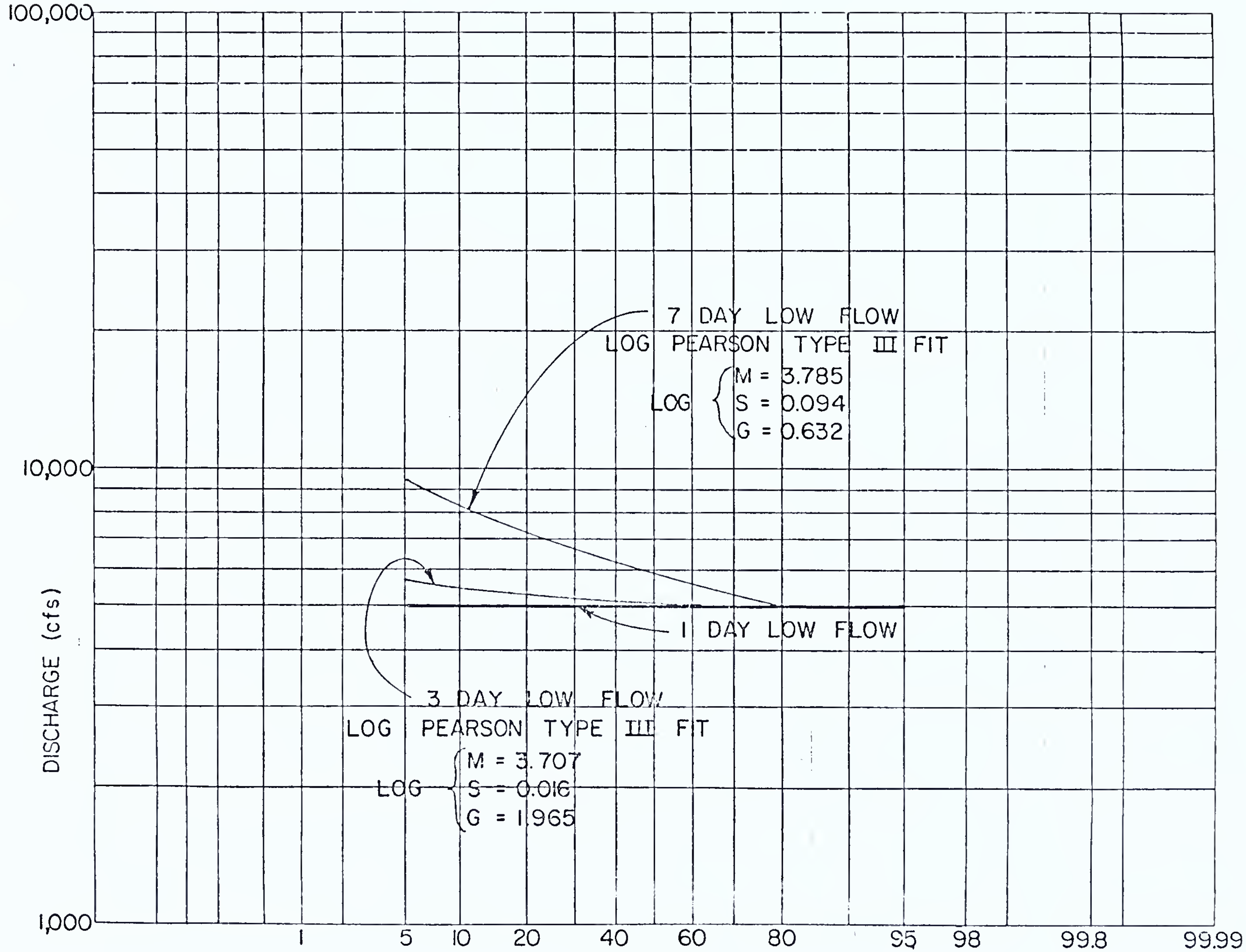

FIGURE 28
LOW FLOW FREQUENCY CURVES
SUSQUEHANNA RIVER AT CONOWINGO OUTFLOW
SIMULATED RELEASE REQUIREMENT NO. 2

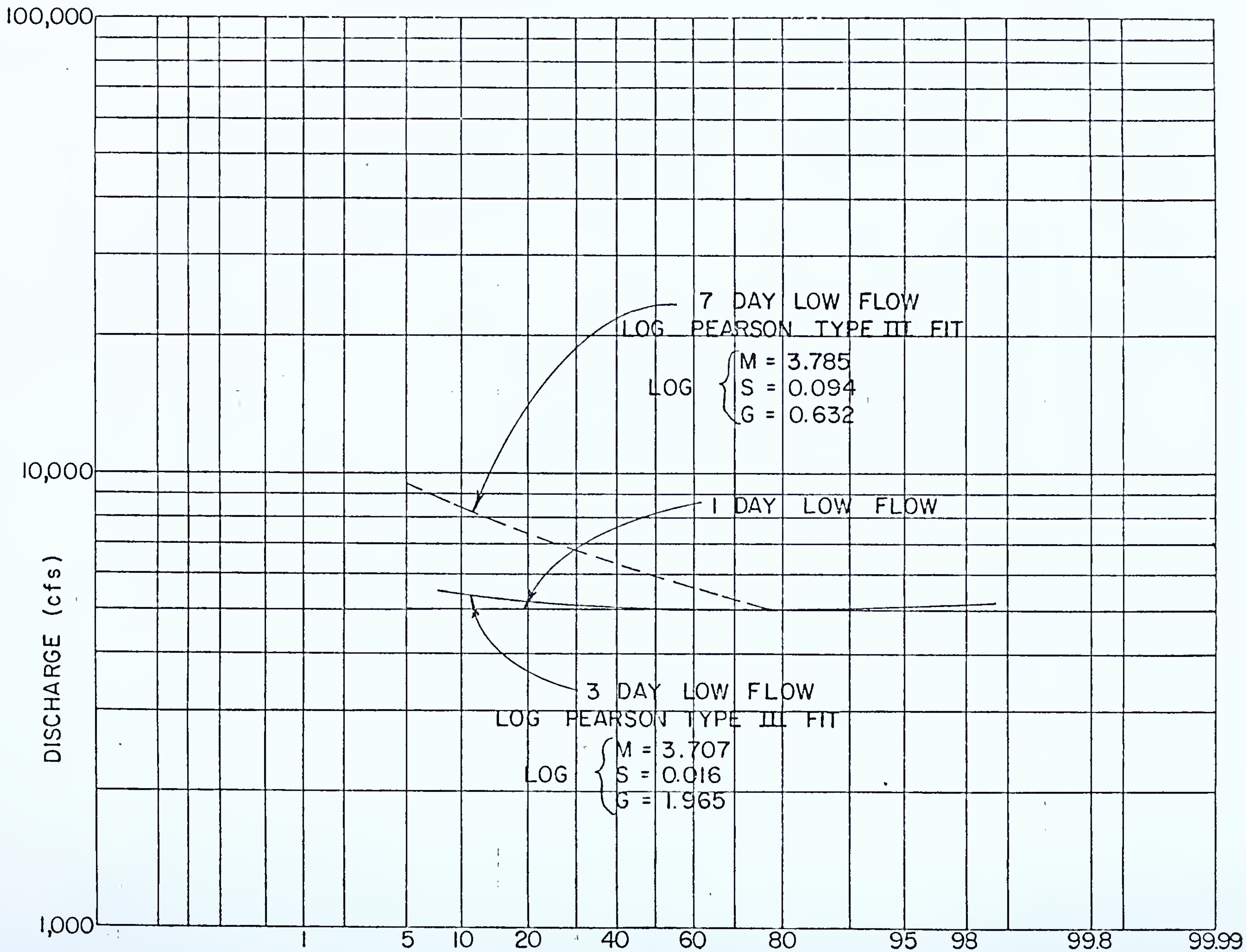

FIGURE 29
LOW FLOW FREQUENCY CURVES
SUSQUEHANNA RIVER AT CONOWINGO OUTFLOW
SIMULATED RELEASE REQUIREMENT NO. 3

However, when inflows are less than 5,000 cfs, the 5,000 cfs release requirement probably could not be met. This would have to be investigated further. Other combinations of operating schedule and minimum release requirements might be possible.

B. Revisions to Program and Removal of Flow Augmentation Requirement

The release requirements used in the above simulations effectively required the power company to augment flows whenever natural flows are less than the required release. In order to remove the flow augmentation requirement, Maryland Water Resources Administration requested simulation of the following conditions:

1. Minimum release of 5,188 cfs throughout the year, except when natural inflow is less than 5,188 cfs, outflow equals inflow;

2. Minimum release of 15,188 cfs during the period March 1st through May 31st of each year, and 5,188 cfs the remainder of the year, except when natural inflow is less than 5,188 cfs, outflow equals inflow; and

3. Same as number 1 above but with the Baltimore withdrawal equal to 100 mgd (155 cfs) instead of 250 mgd used in the previous simulations.

In the course of running these simulations, two errors in the program were corrected. Firstly, it has been noted previously that elevations as low as 86.0 ft. msl were being computed by the program but the stage-storage table was defined only above elevation 92. To correct this error the stage-storage table was revised to cover the range of elevations from about 30 ft. msl to 118.0 ft. msl. Data for the revision was obtained from a stage-storage curve furnished by Philadelphia Electric Company. The second problem was that the program as originally written would not permit recovery of pool elevation from low levels. Restructuring the elevation storage table also removed this problem.

A third problem was detected with the operating curves. These curves were originally defined as ratios between outflow (water equivalent of the amount of power generation) to inflow for different values of inflow and day of the week. Linear interpolation was used to determine the ratio for intermediate values of inflow. It was found that this scheme was not satisfactory for our purpose, so that the program was modified to provide linear interpolation for actual outflows instead. Also, the original operating curves assumed full-time operation began at 50,000 cfs, rather than at the plant capacity of 86,000 cfs. The curves were revised to reflect full-time oper-

ation beginning at flows exceeding 86,000 cfs. This resulted in some minor changes to Figure 23.

Tables 11 through 16 show the revised count of number of deficits below elevations 107.2 and 99.2 ft. msl and the distributions of deficits by months for the release requirements discussed in the previous section. Tables 17 through 22 show the number of deficits below the same elevations using the release requirements as requested by Maryland.

The changes to the program resulted in only minor changes in the number of deficits below elevations 107.2 ft. msl and 99.2 ft. msl. There were significant changes in the mean deficits but these tables are not included. It is the judgment of the staff that such mean deficits are not meaningful because the pool is completely emptied.

There is very little difference in the number of deficits below the control elevations using the various release requirements presented in Tables 17 through 22. Again, the storage is completely depleted. Changing the Baltimore withdrawal from 100 mgd to 250 mgd has negligible effect because it adds 150 mgd (about 234 cfs) to the release on each day. Such a difference in the Baltimore withdrawal is equivalent to about 4.7% of the 5,000 cfs release.

Flow duration and low flow frequency curves are not included for these cases, for the sake of brevity.

The Commission's Comprehensive Plan includes a guideline stating: "Low flows to the Chesapeake Bay shall not be reduced. Low flow to the Chesapeake Bay is defined as the one-in-twenty year low flow in the months of August, September and October. (The flows of 3,500 cfs, 3,050 cfs and 2,820 cfs into Conowingo Reservoir during August, September and October respectively are selected surrogates for low flow into the Bay... during these months)."

In order to determine the effect of this guideline on Conowingo operations, minimum releases of 3,500 cfs and 2,500 cfs were simulated. These results are shown in Tables 23 through 26. While the total number of deficits has been reduced somewhat, indications are that the storage will be substantially depleted, even for these relatively small minimum releases.

In order to provide a basis for comparison of the effects of the release requirement, a simulation was made with no release requirement and with the withdrawals discussed above. The results are shown in Tables 27 and 28 and indicate a significant number of occasions when the existing operating conditions result in depletion of storage over the period simulated.

TABLE 11

DISTRIBUTION OF NUMBER OF DEFICITS
BELOW ELEVATION 107.2 MSL
OCCURRING ON WEEKENDS
EXISTING RELEASE REQUIREMENT

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	4	5	5	7	0	21
1962	0	0	5	9	9	8	10	0	41
1963	0	0	3	7	8	9	9	0	36
1964	0	0	10	8	8	10	8	0	44
1965	0	0	10	8	9	9	8	0	44
1966	0	0	8	7	10	8	8	0	41
1967	0	0	7	7	10	8	9	0	41
1968	0	0	6	9	8	9	9	0	41
1969	0	0	6	9	8	10	8	0	41
1970	0	0	6	7	8	10	8	0	39
1971	0	0	7	7	9	9	8	0	40
1972	0	0	6	7	6	5	9	0	33
1973	0	0	8	9	9	8	10	0	44
1974	0	0	3	9	8	9	9	0	38
TOTAL	0	0	85	107	115	117	120	0	544

TABLE 12

DISTRIBUTION OF NUMBER OF DEFICITS
BELOW ELEVATION 99.2 MSL
EXISTING RELEASE REQUIREMENT

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	0	0	0	0	0	0
1962	0	0	1	27	31	31	30	31	151
1963	0	0	0	0	10	5	11	15	41
1964	0	0	0	26	31	31	30	31	149
1965	0	24	24	30	31	31	30	31	201
1966	0	0	0	11	31	31	30	31	134
1967	0	0	0	5	17	30	29	31	112
1968	0	0	0	0	6	0	0	4	10
1969	2	0	0	10	16	12	4	0	44
1970	0	0	0	3	17	14	14	19	67
1971	0	0	0	11	31	28	29	31	130
1972	0	0	0	0	0	0	0	0	0
1973	0	0	0	12	30	29	28	30	129
1974	0	0	0	6	0	1	8	15	30
TOTAL	2	24	25	141	251	243	243	269	1198

TABLE 13

DISTRIBUTION OF NUMBER OF DEFICITS
BELOW ELEVATION 107.2 MSL
OCCURRING ON WEEKENDS
RELEASE REQUIREMENT:
15,188 CFS SPRING - 5,000 CFS REMAINDER

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	4	9	8	9	0	30
1962	0	0	6	9	9	8	10	0	42
1963	0	0	8	10	8	9	9	0	44
1964	0	0	10	8	8	10	8	0	44
1965	0	0	10	8	9	9	8	0	44
1966	0	0	9	8	10	8	8	0	43
1967	0	0	8	7	10	8	9	0	42
1968	0	0	8	10	8	9	9	0	44
1969	0	0	9	9	8	10	8	0	44
1970	0	0	6	7	8	10	8	0	39
1971	0	0	7	8	9	9	8	0	41
1972	0	0	6	7	6	8	9	0	36
1973	0	0	8	9	9	8	10	0	44
1974	0	0	3	9	8	9	9	0	38
TOTAL	0	0	98	113	119	123	122	0	575

TABLE 14

DISTRIBUTION OF NUMBER OF DEFICITS
BELOW ELEVATION 99.2 MSL
RELEASE REQUIREMENT:
15,188 CFS SPRING - 5,000 REMAINDER

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	0	6	27	30	31*	94
1962	0	0	11	30	31*	31*	30*	31*	164
1963	0	0	9	2	30	31	30*	31*	133
1964	0	0	7	30	31*	31*	30*	31*	160
1965	0	24	27	30	31*	31*	30*	31*	204
1966	0	0	18	25	31	31*	30*	31*	166
1967	0	0	0	7	30	31	30	31*	129
1968	21	30	31	30	31*	31*	30*	31*	235
1969	21	30	31	30	31*	31*	30*	31*	235
1970	0	0	0	2	23	31	30	31*	117
1971	0	0	0	15	31	31	30*	31*	138
1972	0	0	0	0	0	13	30	31	74
1973	0	0	0	12	30	31	30	31*	134
1974	0	0	0	6	5	30	30	31*	102
TOTAL	42	84	134	219	341	411	420	434	2085

*Below tabled values--not valid.

TABLE 15

DISTRIBUTION OF NUMBER OF DEFICITS
BELOW ELEVATION 107.2 MSL
OCCURRING ON WEEKENDS
RELEASE REQUIREMENT:
5,188 CFS SPRING - 5,000 CFS REMAINDER

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	4	9	8	9	0	30
1962	0	0	5	9	9	8	10	0	41
1963	0	0	3	7	8	9	9	0	36
1964	0	0	10	8	8	10	8	0	44
1965	0	0	10	8	9	9	8	0	44
1966	0	0	8	7	10	8	8	0	41
1967	0	0	7	7	10	8	9	0	41
1968	0	0	6	9	8	9	9	0	41
1969	0	0	6	9	8	10	8	0	41
1970	0	0	6	7	8	10	8	0	39
1971	0	0	7	7	9	9	8	0	40
1972	0	0	6	7	6	8	9	0	36
1973	0	0	8	9	9	8	10	0	44
1974	0	0	3	9	8	9	9	0	38
TOTAL	0	0	85	107	119	123	122	0	556

TABLE 16

DISTRIBUTION OF NUMBER OF DEFICITS
BELOW ELEVATION 99.2 MSL
RELEASE REQUIREMENT:
5,188 CFS SPRING - 5,000 CFS REMAINDER

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	0	6	27	30	31	94
1962	0	0	1	27	31	31*	30*	31*	151
1963	0	0	0	0	28	31	30*	31*	120
1964	0	0	0	26	31	31*	30*	31*	149
1965	0	24	24	30	31*	31*	30*	31*	201
1966	0	0	0	11	31	31*	30*	31*	134
1967	0	0	0	5	29	31	30	31*	126
1968	0	0	0	0	18	31	30	31*	110
1969	2	0	0	10	29	31	30	31*	133
1970	0	0	0	3	25	31	30	31*	120
1971	0	0	0	11	31	31	30*	31*	134
1972	0	0	0	0	0	13	30	31	74
1973	0	0	0	12	30	31	30	31*	134
1974	0	0	0	6	7	30	30	31*	104
TOTAL	2	24	25	141	327	411	420	434	1784

*Below tabled values--not valid.

TABLE 17

DISTRIBUTION OF NUMBER OF DEFICITS
BELOW ELEVATION 107.2 MSL
OCCURRING ON WEEKENDS
RELEASE REQUIREMENT:
15,188 CFS SPRING; 5,188 CFS REMAINDER
EXCEPT IF INFLOW LESS THAN 5,188 CFS RELEASE INFLOW

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	4	9	8	9	0	30
1962	0	0	6	9	9	8	10	0	42
1963	0	0	8	10	8	9	9	0	44
1964	0	0	10	8	8	10	8	0	44
1965	0	0	10	8	9	9	8	0	44
1966	0	0	9	8	10	8	8	0	43
1967	0	0	8	7	10	8	9	0	42
1968	0	0	8	10	8	9	9	0	44
1969	0	0	9	9	8	10	8	0	44
1970	0	0	6	7	8	10	8	0	39
1971	0	0	7	8	9	9	8	0	41
1972	0	0	6	7	6	8	9	0	36
1973	0	0	8	9	9	8	10	0	44
1974	0	0	3	9	8	9	9	0	38
TOTAL	0	0	98	113	119	123	122	0	575

TABLE 18

DISTRIBUTION OF NUMBER OF DEFICITS
BELOW ELEVATION 99.2 MSL
RELEASE REQUIREMENT:
15,188 CFS SPRING; 5,188 CFS REMAINDER
UNLESS INFLOW LESS THAN 5,188 CFS RELEASE INFLOW

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	0	8	29	30	31	98
1962	0	0	11	30	31	31	30	31*	164
1963	0	0	9	3	31	31	30	31	135
1964	0	0	7	30	31*	31*	30*	31*	160
1965	0	24	27	30	31	31	30*	31*	204
1966	0	0	18	25	31	31	30	31	166
1967	0	0	0	8	30	31	30*	31*	130
1968	21	30	31	30	31*	31*	30*	31*	235
1969	21	30	31	30	31*	31*	30*	31*	235
1970	0	0	0	8	25	31	30	31*	120
1971	0	0	0	16	31	31	30*	31*	139
1972	0	0	0	0	0	14	30	31	75
1973	0	0	0	12	30	31	30	31*	134
1974	0	0	0	6	7	30	30	31*	104
TOTAL	42	84	134	223	348	414	420	434	2099

*Below tabled values-not valid.

TABLE 19

DISTRIBUTION OF NUMBER OF DEFICITS
BELOW ELEVATION 107.2 MSL
OCCURRING ON WEEKENDS
RELEASE REQUIREMENT:
5,188 CFS ALL YEAR EXCEPT IF INFLOW LESS
THAN 5,188 CFS RELEASE INFLOW

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	4	9	8	9	0	30
1962	0	0	5	9	9	8	10	0	41
1963	0	0	3	7	8	9	9	0	36
1964	0	0	10	8	8	10	8	0	44
1965	0	0	10	8	9	9	8	0	44
1966	0	0	8	7	10	8	8	0	41
1967	0	0	7	7	10	8	9	0	41
1968	0	0	6	9	8	9	9	0	41
1969	0	0	6	9	8	10	8	0	41
1970	0	0	6	7	8	10	8	0	39
1971	0	0	7	7	9	9	8	0	40
1972	0	0	6	7	6	8	9	0	36
1973	0	0	8	9	9	8	10	0	44
1974	0	0	3	9	8	9	9	0	38
TOTAL	0	0	85	107	119	123	122	0	556

TABLE 20

DISTRIBUTION OF NUMBER OF DEFICITS
BELOW ELEVATION 99.2 MSL
RELEASE REQUIREMENT:
5,188 CFS ALL YEAR EXCEPT IF INFLOW
LESS THAN 5,188 CFS RELEASE INFLOW

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	0	8	29	30	31	98
1962	0	0	1	27	31	31	30	31	151
1963	0	0	0	0	28	31	30	31	120
1964	0	0	0	26	31	31	30	31	149
1965	0	24	24	30	31	31	30	31	201
1966	0	0	0	11	31	31	30	31	134
1967	0	0	0	5	30	31	30	31*	127
1968	0	0	0	0	19	31	30	31	111
1969	2	0	0	10	29	31	30	31	133
1970	0	0	0	3	25	31	30	31*	120
1971	0	0	0	11	31	31	30*	31*	134
1972	0	0	0	0	0	14	30	31	75
1973	0	0	0	12	30	31	30	31*	134
1974	0	0	0	6	7	30	30	31*	104
TOTAL	2	24	25	141	331	414	420	434	1791

*Below tabled values--not valid.

TABLE 21

DISTRIBUTION OF NUMBER OF DEFICITS
BELOW ELEVATION 107.2 MSL
OCCURRING ON WEEKENDS
RELEASE REQUIREMENT:
5,188 CFS ALL YEAR EXCEPT WHEN INFLOW
IS LESS THAN 5,188 CFS RELEASE INFLOW
REDUCED BALTIMORE WITHDRAWAL

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	4	9	8	9	0	30
1962	0	0	5	9	9	8	10	0	41
1963	0	0	3	7	8	9	9	0	36
1964	0	0	10	8	8	10	8	0	44
1965	0	0	10	8	9	9	8	0	44
1966	0	0	8	7	10	8	8	0	41
1967	0	0	7	7	10	8	9	0	41
1968	0	0	6	8	8	9	9	0	40
1969	0	0	6	9	8	10	8	0	41
1970	0	0	6	7	8	10	8	0	39
1971	0	0	7	7	9	9	8	0	40
1972	0	0	6	7	6	8	9	0	36
1973	0	0	8	9	9	8	10	0	44
1974	0	0	3	9	8	9	9	0	38
TOTAL	0	0	85	106	119	123	122	0	555

TABLE 22

DISTRIBUTION OF NUMBER OF DEFICITS
BELOW ELEVATION 99.2 MSL
RELEASE REQUIREMENT:
5,188 CFS ALL YEAR EXCEPT WHEN
INFLOW IS LESS THAN 5,188 CFS RELEASE INFLOW
REDUCED BALTIMORE WITHDRAWAL

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	0	8	28	30	31	97
1962	0	0	1	26	31	31	30	31	150
1963	0	0	0	0	28	31	30	31	120
1964	0	0	0	26	31	31	30	31	149
1965	0	24	22	30	31	31	30	31	199
1966	0	0	0	11	31	31	30	31	134
1967	0	0	0	4	29	31	30	31	125
1968	0	0	0	0	18	31	30	31	110
1969	2	0	0	10	29	31	30	31	133
1970	0	0	0	3	24	31	30	31	119
1971	0	0	0	11	31	31	30	31	134
1972	0	0	0	0	0	13	30	31	74
1973	0	0	0	12	30	31	30	31	134
1974	0	0	0	6	7	30	30	31	104
TOTAL	2	24	23	139	328	412	420	434	1782

TABLE 23

DISTRIBUTION OF NUMBER OF DEFICITS
BELOW ELEVATION 107.2 MSL
OCCURRING ON WEEKENDS
RELEASE REQUIREMENT:
3,500 CFS ALL YEAR

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	4	8	8	9	0	29
1962	0	0	5	9	9	8	10	0	41
1963	0	0	3	7	8	9	9	0	36
1964	0	0	10	8	8	10	8	0	44
1965	0	0	10	8	9	9	8	0	44
1966	0	0	8	7	10	8	8	0	41
1967	0	0	7	6	10	8	9	0	40
1968	0	0	5	8	8	9	9	0	39
1969	0	0	5	9	8	10	8	0	40
1970	0	0	6	7	8	10	8	0	39
1971	0	0	7	7	9	9	8	0	40
1972	0	0	6	7	6	7	9	0	35
1973	0	0	8	9	9	8	10	0	44
1974	0	0	3	8	6	9	9	0	35
TOTAL	0	0	83	104	116	122	122	0	547

TABLE 24

DISTRIBUTION OF NUMBER OF DEFICITS
BELOW ELEVATION 99.2 MSL
RELEASE REQUIREMENT:
3,500 CFS ALL YEAR

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	0	1	5	27	31	64
1962	0	0	0	18	31	31	30	31	141
1963	0	0	0	0	15	31	30	31	107
1964	0	0	0	20	31	31	30	31	143
1965	0	24	22	29	31	31	30	31	198
1966	0	0	0	5	31	31	30	31	128
1967	0	0	0	1	24	31	30	31	117
1968	0	0	0	0	10	31	30	31	102
1969	0	0	0	2	16	24	30	31	103
1970	0	0	0	0	15	26	30	31	102
1971	0	0	0	1	29	31	30	31	122
1972	0	0	0	0	0	4	29	31	64
1973	0	0	0	12	30	31	30	31	134
1974	0	0	0	4	0	21	30	31	86
TOTAL	0	24	22	92	264	359	416	434	1611

TABLE 25

DISTRIBUTION OF NUMBER OF DEFICITS
BELOW ELEVATION 107.2 MSL
OCCURRING ON WEEKENDS
RELEASE REQUIREMENT:
2,500 CFS ALL YEAR

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	4	6	6	9	0	25
1962	0	0	5	9	9	8	10	0	41
1963	0	0	3	6	8	9	9	0	35
1964	0	0	9	8	8	10	8	0	43
1965	0	0	10	8	9	9	8	0	44
1966	0	0	8	7	10	8	8	0	41
1967	0	0	7	4	10	8	9	0	38
1968	0	0	5	8	8	9	9	0	39
1969	0	0	5	7	8	10	8	0	38
1970	0	0	6	5	8	10	8	0	37
1971	0	0	7	7	9	9	8	0	40
1972	0	0	6	7	6	7	9	0	35
1973	0	0	8	9	9	8	10	0	44
1974	0	0	3	8	6	9	9	0	35
TOTAL	0	0	82	97	114	120	122	0	535

TABLE 26

DISTRIBUTION OF NUMBER OF DEFICITS
BELOW ELEVATION 99.2 MSL
RELEASE REQUIREMENT:
2,500 CFS ALL YEAR

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	0	0	0	6	30	36
1962	0	0	0	6	30	31	30	31	128
1963	0	0	0	0	4	29	30	31	94
1964	0	0	0	15	31	31	30	31	138
1965	0	24	21	29	31	31	30	31	197
1966	0	0	0	1	25	31	30	31	118
1967	0	0	0	0	14	30	30	31	105
1968	0	0	0	0	3	26	30	31	90
1969	0	0	0	0	4	11	27	31	73
1970	0	0	0	0	9	21	30	31	91
1971	0	0	0	0	20	28	30	31	109
1972	0	0	0	0	0	1	22	31	54
1973	0	0	0	12	30	31	30	31	134
1974	0	0	0	0	0	5	26	31	62
TOTAL	0	24	21	63	201	306	381	433	1429

TABLE 27

DISTRIBUTION OF NUMBER OF DEFICITS
BELOW ELEVATION 107.2 MSL
OCCURRING ON WEEKENDS
NO RELEASE REQUIREMENT

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	4	5	5	7	0	21
1962	0	0	4	7	9	8	10	0	38
1963	0	0	3	5	8	9	9	0	34
1964	0	0	9	8	8	10	8	0	43
1965	0	0	10	8	9	9	8	0	44
1966	0	0	8	6	10	8	8	0	40
1967	0	0	7	4	8	8	9	0	36
1968	0	0	5	8	8	9	8	0	38
1969	0	0	5	7	7	6	8	0	33
1970	0	0	6	4	7	9	8	0	34
1971	0	0	7	5	9	6	7	0	34
1972	0	0	6	7	6	5	9	0	33
1973	0	0	8	9	9	8	10	0	44
1974	0	0	3	5	3	8	8	0	27
TOTAL	0	0	81	87	106	108	117	0	499

TABLE 28

DISTRIBUTION OF NUMBER OF DEFICITS
BELOW ELEVATION 99.2 MSL
NO RELEASE REQUIREMENT

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1961	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	8	8
1963	0	0	0	0	0	0	0	0	0
1964	0	0	0	1	0	0	0	0	1
1965	0	24	21	22	31	31	30	31	190
1966	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	1	10	9	13	33
1968	0	0	0	0	0	0	0	1	1
1969	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	2	0	0	2	4
1971	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0
1973	0	0	0	12	30	29	28	30	129
1974	0	0	0	0	0	0	2	3	5
TOTAL	0	24	21	35	64	70	69	88	371

C. Considerations in Establishing a Release Requirement

It is apparent from the above results that Conowingo pool has insufficient storage to meet the demands resulting from the multiple purposes for which it might be operated. The existing storage cannot simultaneously meet the needs for hydropower peaking generation, year-round minimum release, water supply withdrawals and pool elevation for recreation and fishery purposes. The existence of such conflicts requires that reasoned choices be made between these purposes. Such reasoned choices need to consider:

1. The effect of minimum releases on the fishery downstream from Conowingo.

2. The need for Baltimore and Chester to withdraw water from Conowingo during low river flows.

3. The need to maintain pool elevation above 99.2 ft. msl for power generation at Conowingo, Muddy Run and Peach Bottom.

4. The need for recreation access to the pool during low river flows.

5. The effect of fluctuations in pool elevations on the fishery in the pool.

6. The effect of the release requirement on hydropower generation at Conowingo.

7. The effect of the water supply withdrawals on pool elevations at Conowingo.

8. The effects of Holtwood and Safe Harbor on flows, the effects of changes at Conowingo on Holtwood and Safe Harbor; and the impact of Muddy Run on Conowingo operation.

Withdrawal of water by the City of Baltimore has occurred on only a few occasions in the past. However, there are indications that such withdrawal will occur under future conditions. The interaction of Holtwood and Safe Harbor with Conowingo has not been addressed, because of difficulty in resolving certain operational questions with the power company in time to complete this study. The remaining problems can best be addressed by various agencies, using the results of the simulation analyses. In particular, in order to evaluate the need for a release requirement it was deemed necessary to conduct a separate study of the effects of releases on the fishery.

An additional problem is posed by the characteristics of the existing turbines at Conowingo. The small turbines have a

maximum physical efficiency at a turbine discharge of about 5,000 cfs. It is questionable whether a release significantly less than 5,000 cfs can be provided with the existing equipment without serious damage to the equipment. If such a release requirement were imposed the options open to the company would be:

1. Operate with existing equipment at low efficiency and accept the damage to the equipment.

2. Operate with existing equipment but do not generate (i.e. operate at speed-no load condition). In effect this means no generation from the release.

3. Replace one or more existing turbines with equipment having operating characteristics which will permit efficient operation at low turbine flow rates.

4. Install control or gate equipment necessary to discharge water through the dam.

D. Simulation of Tradeoffs Between Purposes

In order to provide information on the full range of tradeoffs among the various uses discussed for the Conowingo pool, the Maryland Water Resources Administration requested the following simulations:

1. Assume a minimum flow release and compute reservoir volume deficits below the control elevations of 107.2 ft. msl and 99.2 ft. msl, respectively.

a. Minimum release of 2,500 cfs during spawning period, zero remainder of time, Baltimore withdrawal 100 cfs;

b. Minimum release of 5,000 cfs during spawning period, with Baltimore withdrawal of 100 mgd;

c. Minimum release of 5,000 cfs during spawning period, Baltimore withdrawal at 250 mgd;

d. Minimum release of 2,500 cfs year round with Baltimore withdrawal at 100 mgd;

e. Minimum release of 5,000 cfs throughout the year with Baltimore withdrawal at 100 mgd;

f. Minimum release of 5,000 cfs year round, except outflow equals inflow when inflow less than 5,000 cfs, Baltimore withdrawal at 250 mgd; and

g. Minimum release 15,000 cfs during the period March through May, with 5,000 cfs minimum release remainder of year.

2. Maintain a predetermined minimum pool elevation and compute the corresponding releases:

a. Minimum pool elevation 102.0, Baltimore withdrawal 100 cfs;

b. Minimum pool elevation 99.2, Baltimore withdrawal 100 cfs;

c. Minimum pool elevation 107.2, Baltimore withdrawal 100 cfs; and

d. Minimum pool elevation 99.2, Baltimore withdrawal 500 mgd (774 cfs).

To each of the above minimum releases, an attraction flow of 188 cfs was added during the spawning period (March through June). Also, all simulations were run with the withdrawals for Peach Bottom and Chester and the evaporative loss from the pool fixed as discussed in Subsection IV.A.

In addition to the above, Maryland Water Resources Administration requested that the effects of releases from existing storage reservoirs be evaluated. Such a study would require considerable time and a flow routing model would have to be available for the entire basin. At the present time, (November 1979) the flow routing model would permit evaluation only of effects of releases from Raystown Reservoir. However, the period of record used in calibration of that model does not correspond with the period of record being simulated at Conowingo. Thus, either the period of record being studied at Conowingo would have to be changed or the routing model would have to be revised. Neither alternative was found to be feasible at this time due to time and cost constraints and so the effects of upstream releases will have to be evaluated at a later date.

1. Revisions to Computer Model with Fixed Releases

In order to make the simulations requested by Maryland and provide a good basis for comparison it was necessary to incorporate Muddy Run into the daily flow simulations. The resulting water balance model becomes:

$$S2 = S1 + QNET - QMUDIN - QMUDOUT - QOUT \qquad \ldots(6)$$

In this equation, S2 is the storage at the end of a given day, S1 is the storage at the end of the previous day, QNET is the

inflow on the day being considered minus the assumed withdrawals, QMUDIN is the amount of water pumped to Muddy Run, QMUDOUT is the amount of water used for generating electricity at Muddy Run, and QOUT is the amount of water released at Conowingo.

Initially, the following constraints were imposed on Muddy Run operations:

a. No generation when Conowingo pool is at or above 109.2 ft. msl;

b. No generation when Conowingo pool is at or below 100.0 ft. msl;

c. No generation when Muddy Run upper pool is at or below elevation 470 ft. msl;

d. No pumpage to Muddy Run when Muddy Run upper pool is at or above elevation 520 ft. msl; and

e. No pumpage to Muddy Run when Conowingo is at or below elevation 102.0 ft. msl.

Typical Muddy Run operating curves are shown in the Conowingo Relicensing Application (5) for flows of 2,500, 5,000 and 15,000 cfs. These curves were integrated to obtain an average flow for each day and under each of the flow conditions given. The resulting values are shown in Tables 29 and 30 along with the ratio of the daily flow to the sum of daily flows for an entire week. Notice that the amount of flow used for pumping and generation is nearly constant regardless of the inflow to Conowingo. Also, the pumping and generation flows are not balanced over a weekly period.

Philadelphia Electric Company was requested to explain the discrepancy between pumping and generation flows, and to provide similar information for other Conowingo inflows. An official response was not received until December 1978, but the studies described in this section proceeded on the basis of an unofficial response which suggested two things:

1. The average flow ratios shown in Tables 29 and 30 could be used to distribute a total flow of 33,600 cfs days over the 7-day period.

2. Typical Muddy Run operation might involve generating with the equivalent of 25 feet of drawdown during the period Monday through Friday, with the equivalent of 20 feet of storage being pumped during the period Monday through Thursday and the remaining amount of water being pumped over the weekend so that the upper pool is full on Monday morning. In effect this results in total pumpage and total generation of 33,600 cfs days each week.

TABLE 29
MUDDY RUN PUMPAGE
(From Conowingo Relicensing Application (5))

CONOWINGO INFLOW (CFS)

DAY	2500 Daily Flow (cfs)	2500 R	5000 Daily Flow (cfs)	5000 R	15000 Daily Flow (cfs)	15000 R	Average Daily Flow (cfs)	Average R
Mon.	6284	.140	6533	.137	7217	.143	6820	0.142
Tues.	5573	.124	4972	.104	6094	.125	5650	0.118
Wed.	5438	.121	5399	.113	6038	.124	5730	0.119
Thurs.	5280	.118	5783	.122	6066	.125	5850	0.122
Fri.	5415	.121	5905	.124	5869	.121	5860	0.122
Sat.	6148	.137	7379	.155	6234	.128	6720	0.140
Sun.	10684	.238	11618	.244	11079	.228	11370	0.237
Sum of Daily Flows	44822		47589		48597		48000	

Average Pumpage = 47002

$$R = \frac{\text{Daily Flow}}{\text{Sum of Daily Flows}}$$

TABLE 30
MUDDY RUN GENERATION
(From Conowingo Relicensing Application

CONOWINGO INFLOW (CFS)

DAY	2500 Daily Flow (cfs)	2500 R	5000 Daily Flow (cfs)	5000 R	15000 Daily Flow (cfs)	15000 R	Average Daily Flow (cfs)	Average R
Mon.	9251	.1836	10502	.2265	10826	.2068	9870	0.2056
Tues.	13448	.2668	12944	.2791	13382	.2556	12820	0.2672
Wed.	10153	.2015	9665	.2084	10657	.2036	9820	0.2045
Thurs.	9567	.1898	6446	.1390	9717	.1856	8230	0.1715
Fri.	7435	.1475	6359	.1371	7119	.1360	6730	0.1402
Sat.	542	.0108	454	.0098	646	.0123	530	0.0110
Sun.	0	0	0	0	0	0	0	0
Sum of Daily Flows	50396		46370		52347		48000	

Average of Generation = 49704

A comparison of these suggested operating assumptions is shown in Table 31. There are some significant differences between the individual daily flows for certain days. Since there was no clear indication that either assumption was better than the other, the staff chose the first assumption since it is based on data given in the relicensing application.

Simulation of the combined operation of Muddy Run and Conowingo showed that Muddy Run was not fully utilized and that in many cases Muddy Run pumpage or generation could not occur because of the constraints. The staff contacted Philadelphia Electric Company for advice, and again an official response was not received until December 1978. The studies in this section proceeded on the basis of unofficial discussion indicating that the constraint preventing Muddy Run generation when Conowingo pool is at or above elevation 109.2 ft. msl could be relaxed under certain conditions provided that Holtwood was not generating. However, these conditions could not be considered in a daily flow model. The same discussion indicated the constraint on Muddy Run generation when Conowingo was below elevation 100 msl was not reasonable, so that constraint was removed. That change had minimal effect on the pumpage and generation for Muddy Run.

It appeared the major reason that Muddy Run was not utilized effectively was the use of average daily flows and end of day pool elevations instead of instantaneous flow and pool elevations. It was not deemed feasible to consider a time scale shorter than one day because of time and cost constraints and data requirements. In order to offset the resulting bias, all constraints imposed on Muddy Run by either Muddy Run or Conowingo pool elevations were removed, and the resulting model was used for simulation. Note that all diurnal fluctuations in pool elevations and flow rates are suppressed, and only the weekly and 8-month annual cycles are shown by the model.

The other problem which had to be studied was whether the operating curves themselves were adequate. The fact that the simulation with no release requirement indicates that the storage is drawn down below elevation 99.2 (Table 28) means that the operating curves are calling for more generation at Conowingo under certain conditions than can be obtained.

A rerun of that case with the revisions noted above, including the Muddy Run operation, showed that the number of deficits below elevation 99.2 ft. msl was reduced to 47 occurrences out of the 3,430 days simulated. This still indicates a problem but it is considerably less significant. When Muddy Run operation is included, but the Baltimore withdrawal is not included, the number of occurrences of pool elevations below 99.2 is reduced to two.

TABLE 31

COMPARISON OF OPERATING CURVES FROM CONOWINGO REPORT
WITH FIVE FOOT NET DRAWDOWN

	VOLUME OF FLOW					
	FIVE FOOT NET DRAWDOWN			OPERATING CURVE		
DAY	Pump cfs Days	Generate cfs Days	Net Flow cfs Days	Pump cfs Days	Generate cfs Days	Net Flow cfs Days
Mon.	7525	9680	+2155	4771	6910	+2139
Tues.	6882	9038	+2156	3967	8978	+5011
Wed.	6466	8394	+1928	4020	6871	+2851
Thurs.	6050	7979	+1929	4078	5761	+1683
Fri.	4537	7562	+3025	4096	4711	+ 615
Sat.	4954	0	-4954	4711	370	-4341
Sun.	6239	0	-6239	7958	0	-7958
SUM	42653	42653		33601	33601	

The operating curves were based on the concept that flows were balanced over the week. The results of simulations without a release requirement indicated that the true flow balance was not maintained. It was thought that this might be due to a rising or falling inflow hydrograph so that a forecasting algorithm might solve the problem. An algorithm was inserted in the program which computed the average weekly flow, using the average daily inflows observed for seven days beginning on the first Monday in March of each year. This average flow was then used to determine the outflow while the actual QNET for each day was inserted into equation (6). The results of a simulation with the above concept in the program showed even greater fluctuations in pool elevations under zero minimum release conditions, than for the case without the forecasting algorithm. The reason for this can be seen by considering, for example, a steeply rising inflow hydrograph during the week. The flows at the beginning of the week are inadequate to support the releases required by the operating curves and the weekly average flow and thus the pool would be drawn down. A more sophisticated forecasting algorithm might solve this problem, but the amount of programming required did not seem justified.

Alternatively, it would be theoretically feasible to calibrate the operating curves using inflow and outflow data. However, the outflow data is not well qualified as discussed in Section III. Such calibration would require considerable effort. In view of the variability in power operations, depending on Pennsylvania-New Jersey-Maryland Interconnection system requirements, which was observed during the fishery study described in a separate report, it did not seem advisable to attempt such calibration at least for the present purpose. In effect, the operating curves which were considered originally only to be "typical", are at best some kind of average (perhaps median) of a lot of different flows that might be utilized for power generation under specified river flows. The actual operating curves are then a set of quasi-random variable(s) which have considerable scatter.

For these reasons it was decided to use the model without the forecasting algorithm and with the operating curves modified as discussed in subsection E. The problems noted above should be kept in mind when evaluating the results of simulations to be presented.

2. Programs to Simulate Constant Minimum Pool Elevations

The program described above is structured to maintain a constant release and compute the minimum pool elevation. The second part of the evaluation of tradeoffs, as requested by the State of Maryland requires a program which will maintain a constant pool elevation and compute the resulting releases.

A computer program was written to simulate this condition. The program basically follows the same principles as the program which assumes a fixed minimum release except if the operating curves result in a release which will draw down the pool below the minimum allowable for the case being simulated, the amount of release is reduced by the amount of water necessary to maintain the target minimum pool elevation. There is no comparison of actual releases with assumed minimum releases and no adjustment for such minimum releases.

Muddy Run is an additional and perhaps more critical complication in this program. If the Muddy Run pumpage, as determined from the operating curves, is greater than the daily inflow to Conowingo, Muddy Run will draw down the pool. If the pool is already at or near the target elevation, Muddy Run may cause the pool elevation to go below the target elevation. If this happens the algorithm assumes the deficit is made up on the following day, which results in a corresponding reduction of outflow on the following day. The computer output shows negative outflows from Conowingo as a result of this situation.

3. Computation of Effect of Release Requirement and Water Supply Withdrawals on Power Generation

The present operation of Conowingo is essentially as follows:

a. For average daily inflows in excess of 86,000 cfs the plant operates full time as a base load generation station.

b. For average daily inflows less than 86,000 cfs the plant operates in peaking mode with the amount of generation and the timing of the generation dependent on the loads actually experienced by the Pennsylvania-New Jersey-Maryland Interconnection system, the availability of other equipment to meet the system load, and the amount of water available for generation. The amount of water available includes both river flow, which is partially regulated by Holtwood and Safe Harbor, and withdrawal from storage at Conowingo.

Under present conditions, since the Baltimore and Chester withdrawals are not occurring, a minimum release requirement has no effect on inflows exceeding 86,000 cfs. For such inflows the plant is operating full time and is always releasing at least 86,000 cfs. Under future conditions when the Baltimore and Chester withdrawals take place, the same condition will still be approximately true.

The effect of the minimum release requirement is on inflows less than 86,000 cfs. For those inflows the effect is to shift the release that would otherwise be made during the peak demand period to an off-peak period. Thus, the effect of a minimum re-

lease requirement is to reduce present control of river flow and the amount of power generated during peak demand periods and increase the amount of power generated during off-peak periods. In other words, for inflows less than 86,000 cfs the peaking generation capability will be reduced by the establishment of a minimum release requirement, but the base load generation capability will be increased. Thus, the best measure of the effect of release requirement and power generation is to compare the amount of peaking power lost due to the release requirement with that which could have occurred in the absence of a release requirement. The assumption is made that the release requirement is established so as to permit generation using the minimum releases. If this is not the case, the additional base flow generation added will be less than the amount of peaking capacity lost. This is equivalent to assuming that all water available will be used for generation. This is not necessarily true for the 2,500 cfs release, because the existing equipment cannot generate at a 2,500 cfs flow for extended periods.

Figure 30 shows a schematic plot of average daily flows. The solid line represents the average daily flow available for the generation of power under conditions of no release requirement. The dashed line represents the average daily flow released in the generation of power under conditions where the release requirement has been superimposed. For days on which the solid line is above the dashed line, the difference is the amount of peaking capacity lost due to the release requirement. For days on which the dashed line is above the solid line, the difference represents the additional base load generation resulting from the minimum release requirement. The additional base load generation is equal to the lost peaking capacity, assuming that the effective head is the same in both cases. However, power generation economics are such that the value of the peaking capacity lost is considerably greater than the value of the base load capacity gained.

If the amount of peaking capacity lost is summed over the days in which the peaking capacity is lost, the result is a measure in cfs days of the amount of peaking capacity lost for the 8-month period simulated during each year. This can be converted to kilowatts or kilowatt hours of power by using the average plant hydroequivalent of 6.6 Kw/cfs. The percentage of peaking power lost can also be computed.

The amount of peaking capacity that could be obtained in the absence of a release requirement, Baltimore withdrawal, or constraint on minimum Conowingo pool elevations is defined for the present purpose as the base case. The Chester withdrawal, the consumptive loss due to Peach Bottom and the evaporative loss from the pool are included in this base case. The amount of peaking power generation lost is given by the difference between the peaking power computed for the base case and the amount of peaking power generated for the test case being simulated.

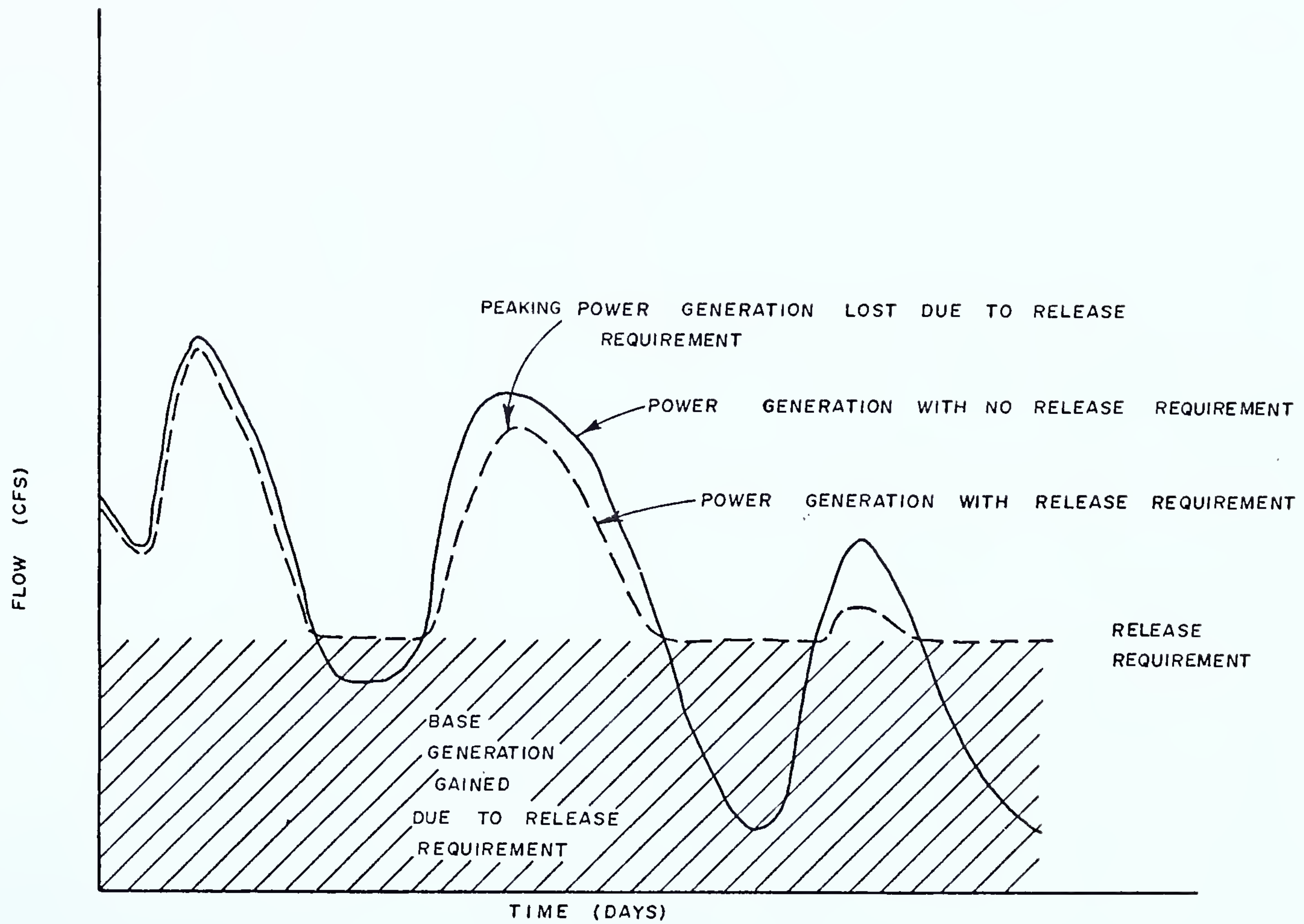

FIGURE 30
SCHEMATIC OF AVERAGE DAILY FLOWS SHOWING AMOUNT OF FLOW USED FOR POWER GENERATION WITHOUT AND WITH RELEASE REQUIREMENT

To compute that quantity it is necessary for the simulation program to mathematically move a certain volume of water from on-peak generation to off-peak generation. That would require changes to the operating curves which could not be made except on a trial and error basis. However, the amount of water which would have to be moved is equal to the increased volume of water which is used for base load generation.

Given the above definitions, the amount of peaking power lost can be computed in one of two ways depending on the definition of base load and peaking generation for the base case. Either of the following definitions might be used.

1. Since the model suppresses diurnal fluctuations of flows, the base load generation for the base case is that which the model shows as occurring full time, i.e., every day during a given week. The peaking generation is that in excess of the base load generation. Since the plant operating procedures will usually result in less generation on weekends as compared with weekdays, the minimum daily generation during any week will generally occur on a Saturday or a Sunday. Then the base load generation for the base case can be considered as that occurring below a line connecting the lowest daily release on successive weekends. The peaking power for the base case then is defined as the amount occurring above that line.

The exception to the general rule occurs when inflows are markedly decreasing or increasing during the week, so that the generation on both Saturday and Sunday may exceed the generation for one or more days during the previous or following week. However, in general there will still be one day of the weekend which will have lower releases than the other, so that a line connecting minimum daily flows on successive weekends can still be constructed.

For this definition the amount of the base load generation added by the release requirement is simply the difference between the release for the case being considered and the release for the base case when that difference is positive, and the sum of those differences over a given period of time represents the amount of peaking power generation lost over that period of time.

2. The operating procedures generally require that the plant will operate in peaking mode at all net inflows less than 86,000 cfs. Thus, all generation and all releases will occur at the peak of the system load curve, and represent peaking power. Therefore, for daily net inflows less than 86,000 cfs, all releases will generate peaking power, in the absence of a release requirement. If the release requirement is imposed, the amount of base load generation due to the release requirement is equal to the amount of the release requirement in appropriate units. This is illustrated in Figure 31.

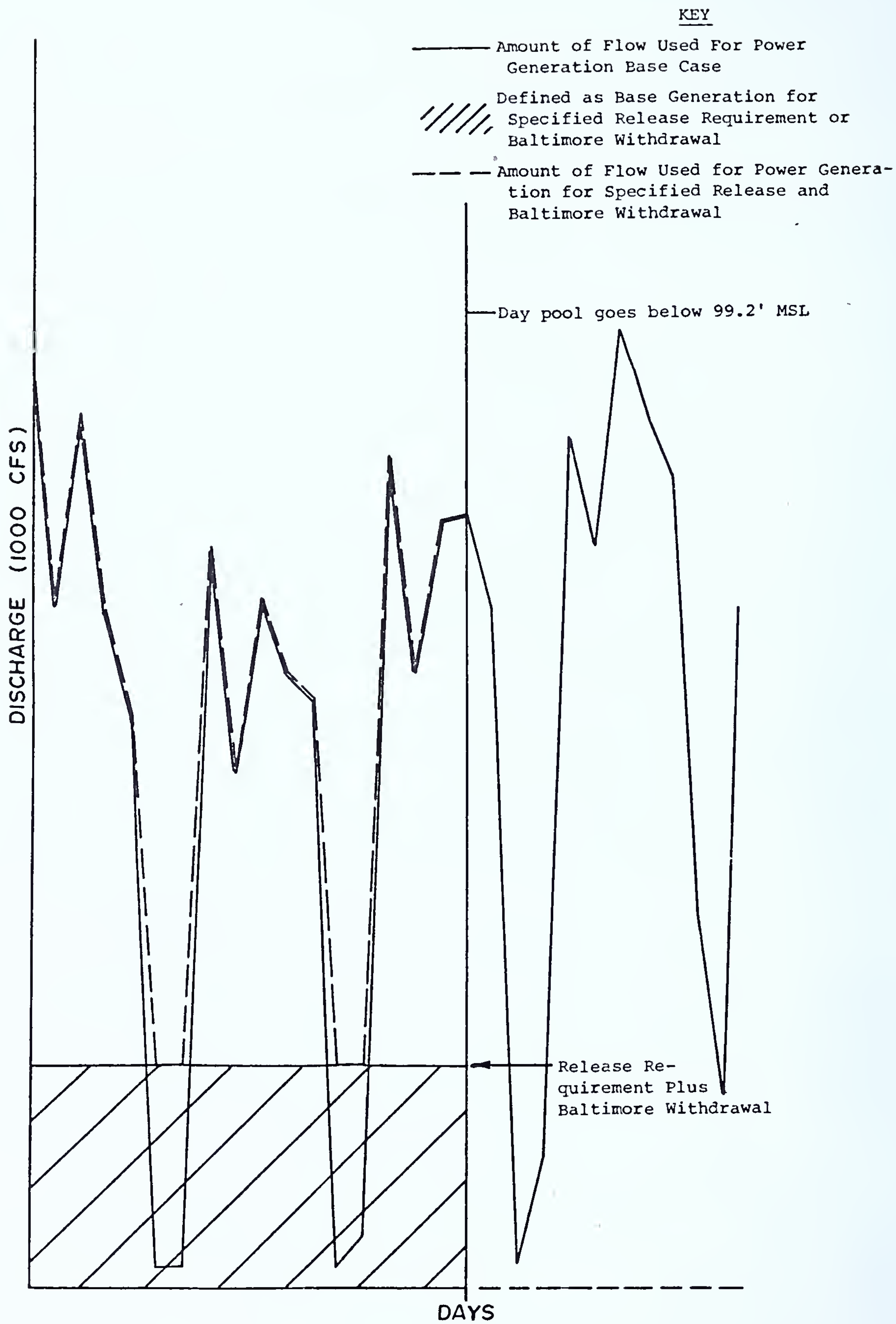

FIGURE 31
PLOT OF AVERAGE DAILY FLOWS
ILLUSTRATING COMPUTATION OF POWER GENERATION LOST

For either definition the amount of the Baltimore withdrawal would be added to the base load generation for the case being considered, and then that total subtracted from the total peaking generation for the base case to obtain the peaking generation lost.

The second definition seems to be more realistic and therefore, it was used in this study. The computation was made for daily inflows less than 50,000 cfs because it was determined that none of the alternatives affected daily inflows in excess of 50,000 cfs. The computation was carried forward until the day on which the pool elevation first went below elevation 99.2 ft. msl for that year. After the pool elevation first went below elevation 99.2 ft. msl, it was assumed that all power generation which occurred for the base case would not occur for the case being considered. The assumption that there is no generation after the pool elevation goes below elevation 99.2 is somewhat arbitrary, and was made in part to facilitate computation.

Computations for loss of power generation were not made for the simulations using fixed minimum pool elevations. These schemes are so close to current operating procedures that the amount of power generation lost would be negligible.

The above computations consider only changes in power generation due to changes in release. Changes in power generation resulting from drawdown of the pool are not considered.

4. Results of Simulations

a. Base Case

Tables 32 and 33 present the number of deficits below elevation 107.2 and 99.2 respectively for the simulated base case. As noted previously, this base case considers no release requirement and no Baltimore withdrawal, but includes Chester and Peach Bottom withdrawals (102 cfs) for the months of March and April and an additional evaporative loss of 50 cfs for the months of May through October. Table 34 shows minimum pool elevations for this base case. Note that there are only two days on which the pool elevation is less than 99.2 ft. msl, and these days occur in October 1965. The minimum pool elevation is 98.92 for that month.

b. Fixed Minimum Release, Compute Minimum Pool Elevation

1) Minimum Release 2,500 cfs March through June, Zero Remainder of Year, Baltimore Withdrawal 100 cfs.

TABLE 32 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL
BASE CASE

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	1	0	0	1	0	0	2
1962	0	0	0	4	9	8	10	0	31
1963	0	0	0	0	2	3	8	0	13
1964	0	0	0	6	8	10	8	0	32
1965	0	0	10	8	9	9	8	0	44
1966	0	0	4	2	10	8	8	0	32
1967	0	0	2	0	7	8	9	0	26
1968	0	0	2	5	8	9	6	0	30
1969	0	0	5	4	8	7	8	0	32
1970	0	0	1	2	3	5	2	0	13
1971	0	0	9	8	9	9	8	0	43
1972	0	0	0	3	0	0	7	0	10
1973	0	0	7	1	5	6	7	0	26
1974	0	0	2	2	0	8	9	0	21
TOTAL	0	0	43	45	78	91	98	0	355

TABLE 33 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL
BASE CASE

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	2	2
1966	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	2	2

TABLE 34 -- MINIMUM ELEVATIONS - BASE CASE

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1961	107.23	107.23	106.67	105.54	105.57	105.62	105.49	106.91
1962	106.10	107.23	105.16	105.74	105.32	105.29	104.61	101.97
1963	107.23	106.44	105.87	105.38	106.71	106.42	105.82	105.56
1964	106.41	107.23	105.39	104.25	104.39	104.16	103.40	103.96
1965	104.94	103.05	102.19	102.32	102.54	101.46	100.55	98.92
1966	107.23	105.94	106.12	105.20	105.49	104.91	104.85	104.10
1967	106.52	106.98	106.36	105.56	102.43	102.03	101.72	100.72
1968	105.14	105.54	105.21	105.08	103.43	104.94	104.74	103.04
1969	105.14	106.33	104.54	104.23	103.28	103.66	104.90	104.75
1970	106.14	107.23	106.61	105.37	104.79	105.35	105.53	103.92
1971	107.23	105.74	103.49	102.33	102.56	103.08	100.99	99.96
1972	107.12	107.23	107.23	106.00	106.49	105.24	105.62	105.49
1973	106.90	105.97	105.40	106.16	104.12	102.74	104.29	104.40
1974	106.56	107.23	106.17	104.97	105.54	104.45	102.44	102.31

Tables 35 and 36 present the number of deficits below elevation 107.2 ft. msl and 99.2 ft. msl, respectively. Table 37 gives the corresponding minimum pool elevations. Note that the pool elevation is less than 99.2 on 202 days and the lowest minimum pool elevation is 92.76 ft. msl in October 1965.

Table 38 shows the amount of peaking power generation lost.

2) Minimum Release 5,000 cfs March through June, Zero Remainder, Baltimore Withdrawal 100 mgd (155 cfs).

Tables 39 and 40 present the number of deficits below elevation 107.2 and 99.2, respectively. Table 41 presents the minimum pool elevations. Notice that for this scheme there are 642 days on which the pool elevation is less than 99.2. The lowest minimum elevation is 84.73 ft. msl in October 1965.

The amount of power generation lost is shown in Table 42.

3) Minimum Release 5,000 cfs March through June, Zero Remainder of Year, Baltimore Withdrawal 250 mgd (388 cfs).

The number of deficits below elevations 107.2 and 99.2 are shown in Tables 43 and 44, respectively. The minimum pool elevations are shown in Table 45. Note that there are 669 days on which the pool elevation is below 99.2, and the minimum pool elevation is 84.42 ft. msl in October 1965.

The amount of power generation lost is summarized in Table 46.

4) Minimum Release 2,500 cfs Year Round, Baltimore Withdrawal 100 mgd (155 cfs).

The number of deficits below elevation 107.2 and 99.2 are presented in Tables 47 and 48, respectively. The minimum pool elevations are presented in Table 49. Note that the pool elevation is below 99.2 on 1087 days, and that the lowest minimum pool elevation reached is 60.40 in October 1965.

The amount of power generation lost is shown in Table 50.

5) Minimum Release 5,000 cfs Year Round, Baltimore Withdrawal 100 mgd (155 cfs).

The number of deficits below elevation 107.2 and 99.2 are shown in Tables 51 and 52, respectively. The minimum pool elevations are shown in Table 53. The value of -8888 in-

TABLE 35 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL
MINIMUM RELEASE 2500 CFS MARCH THROUGH JUNE, ZERO
REMAINDER OF YEAR. BALTIMORE WITHDRAWAL 100 CFS

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	1	0	0	1	0	0	2
1962	0	0	1	9	9	8	10	0	37
1963	0	0	0	2	8	9	9	0	28
1964	0	0	2	8	8	10	8	0	36
1965	0	0	10	8	9	9	8	0	44
1966	0	0	4	5	10	8	8	0	35
1967	0	0	2	1	10	8	9	0	30
1968	0	0	2	5	8	9	7	0	31
1969	0	0	5	7	8	10	8	0	38
1970	0	0	1	2	3	6	4	0	16
1971	0	0	9	8	9	9	8	0	43
1972	0	0	0	3	0	0	7	0	10
1973	0	0	7	1	5	6	7	0	26
1974	0	0	2	3	1	8	9	0	23
TOTAL	0	0	46	62	88	101	102	0	399

TABLE 36 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL
MINIMUM RELEASE 2500 CFS MARCH THROUGH JUNE, ZERO
REMAINDER OF YEAR, BALTIMORE WITHDRAWAL 100 CFS

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	1	1	8	25	35
1963	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	3	9	9	8	29
1965	0	0	0	7	31	31	30	31	130
1966	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	3	5	8
1972	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	7	35	41	50	69	202

TABLE 37 -- MINIMUM POOL ELEVATIONS
MINIMUM RELEASE 2500 CFS MARCH THROUGH JUNE, ZERO
REMAINDER OF YEAR, BALTIMORE WITHDRAWAL 100 CFS

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1961	107.23	107.23	106.67	105.53	105.60	105.68	105.48	106.88
1962	106.10	107.23	104.79	100.61	99.19	99.16	98.41	95.48
1963	107.23	106.44	105.86	105.37	104.53	104.23	103.62	103.34
1964	106.41	107.23	105.42	100.04	98.75	98.47	97.60	98.22
1965	104.94	103.05	102.18	97.38	96.65	95.44	94.47	92.76
1966	107.23	105.93	106.11	103.08	102.10	101.51	101.45	100.72
1967	106.55	106.99	106.36	104.87	101.71	101.28	100.96	99.98
1968	104.05	105.53	105.20	105.07	103.42	104.89	104.71	103.01
1969	104.05	106.34	104.54	103.13	102.16	102.54	103.81	103.66
1970	106.13	107.23	106.60	104.91	104.53	105.14	105.32	103.70
1971	107.23	105.74	103.49	100.95	99.81	100.35	98.04	96.90
1972	107.13	107.23	107.23	105.99	106.48	105.25	105.66	105.53
1973	106.89	105.97	105.41	106.15	104.10	102.71	104.31	104.42
1974	106.56	107.23	106.16	103.86	105.59	104.46	102.40	102.27

TABLE 38

POWER GENERATION LOSS, MINIMUM RELEASE 2500 CFS
MARCH THRU JUNE, ZERO REMAINDER OF YEAR
BALTIMORE WITHDRAWAL 100 CFS

YEAR	PRIOR TO REACHING ELEVATION 99.2			GENERATION LOST AFTER REACHING 99.2
	PEAKING GENERATION LOST (CFS DAYS)	TOTAL GENERATION POSSIBLE (CFS DAYS)	% LOST	
1961	166136	2564818	6.5	0
1962	218186	1565113	13.9	852616
1963	279596	2786970	10.0	0
1964	177948	1197926	14.9	353625
1965	233750	2245301	10.4	612033
1966	238286	2479353	9.6	0
1967	196668	3553795	5.5	0
1968	248892	3252885	7.7	0
1969	308496	3794011	8.1	0
1970	244214	3899117	6.3	0
1971	211518	2616142	8.1	426194
1972	108882	2396525	4.5	0
1973	177096	3726378	4.8	0
1974	252882	4103977	6.2	0
TOTAL	3062550	40182311	7.6	2244468

TABLE 39 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL
MINIMUM RELEASE 5000 CFS MARCH THROUGH JUNE, ZERO
REMAINDER OF YEAR, BALTIMORE WITHDRAWAL 155 CFS

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	1	2	0	1	0	0	4
1962	0	0	2	9	9	8	10	0	38
1963	0	0	0	4	8	9	9	0	30
1964	0	0	2	8	8	10	8	0	36
1965	0	0	10	8	9	9	8	0	44
1966	0	0	4	6	10	8	8	0	36
1967	0	0	2	5	10	8	9	0	34
1968	0	0	2	5	8	9	7	0	31
1969	0	0	5	8	8	10	8	0	39
1970	0	0	1	6	8	10	8	0	33
1971	0	0	9	8	9	9	8	0	43
1972	0	0	0	3	0	0	7	0	10
1973	0	0	7	1	5	6	7	0	26
1974	0	0	2	6	8	9	9	0	34
TOTAL	0	0	47	79	100	106	106	0	438

TABLE 40 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL
MINIMUM RELEASE 5000 CFS MARCH THROUGH JUNE, ZERO
REMAINDER OF YEAR, BALTIMORE WITHDRAWAL 155 CFS

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	0	0	0	0	0	0	0
1962	0	0	0	19	31	31	30	31	142
1963	0	0	0	0	0	0	0	0	0
1964	0	0	0	15	31	31	30	31	138
1965	0	0	0	22	31	31	30	31	145
1966	0	0	0	0	9	15	12	30	66
1967	0	0	0	0	1	5	9	6	21
1968	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0
1971	0	0	0	8	31	30	30	31	130
1972	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	64	134	143	141	160	642

TABLE 41 -- MINIMUM ELEVATION
MINIMUM RELEASE 5000 CFS MARCH THROUGH JUNE, ZERO
REMAINDER OF YEAR, BALTIMORE WITHDRAWAL 155

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1961	107.23	107.23	106.67	105.52	105.62	105.72	105.47	106.85
1962	106.10	107.23	102.84	92.30	90.78	90.75	90.01	86.94
1963	107.23	106.44	105.86	103.58	102.05	101.73	101.13	100.83
1964	106.42	107.23	105.43	93.13	91.83	91.54	90.67	91.28
1965	104.93	103.05	101.73	89.95	89.18	87.90	86.91	84.73
1966	107.23	105.92	106.11	99.28	98.16	97.50	97.41	96.61
1967	106.56	106.99	106.36	102.38	99.12	98.62	98.26	97.19
1968	102.71	105.52	104.99	105.07	103.41	104.87	104.70	103.00
1969	101.61	106.35	104.54	100.95	99.91	100.31	101.59	101.44
1970	106.13	107.23	106.59	103.67	102.11	102.76	102.94	101.31
1971	107.23	105.74	103.49	96.63	95.24	95.84	93.47	92.33
1972	107.14	107.23	107.23	105.99	106.48	105.25	105.69	105.55
1973	106.89	105.98	105.41	106.15	104.10	102.69	104.32	104.43
1974	106.56	107.23	106.16	101.15	103.38	102.42	100.33	100.20

TABLE 42

POWER GENERATION LOSS, MINIMUM RELEASE 5000 CFS
MARCH THRU JUNE, ZERO REMAINDER OF YEAR
BALTIMORE WITHDRAWAL 100 MGD (155 CFS)

YEAR	PRIOR TO REACHING ELEVATION 99.2			GENERATION LOST AFTER REACHING 99.2
	PEAKING GENERATION LOST (CFS DAYS)	TOTAL GENERATION POSSIBLE (CFS DAYS)	% LOST	
1961	290431	2564818	11.3	0
1962	285190	1273711	22.4	1144018
1963	503536	2786970	18.1	0
1964	235985	931119	25.3	620432
1965	372210	2123775	17.5	733559
1966	389309	1916329	20.3	563024
1967	320604	1957368	16.4	1596427
1968	447172	3252885	13.7	0
1969	557986	3794011	14.7	0
1970	437439	3899117	11.2	0
1971	284990	1641466	17.4	1400870
1972	186252	2396525	7.8	0
1973	311611	3726378	8.4	0
1974	453717	4103977	11.1	0
TOTAL	5076432	36368449	14.0	6058330

TABLE 43 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL
MINIMUM RELEASE 5000 CFS MARCH THROUGH JUNE, ZERO
REMAINDER OF YEAR, BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	1	2	0	1	0	0	4
1962	0	0	2	9	9	8	10	0	38
1963	0	0	0	4	8	9	9	0	30
1964	0	0	2	8	8	10	8	0	36
1965	0	0	10	8	9	9	8	0	44
1966	0	0	4	6	10	8	8	0	36
1967	0	0	2	6	10	8	9	0	35
1968	0	0	2	5	8	9	7	0	31
1969	0	0	5	8	8	10	8	0	39
1970	0	0	1	7	8	10	8	0	34
1971	0	0	9	8	9	9	8	0	43
1972	0	0	0	3	0	0	7	0	10
1973	0	0	7	1	5	6	7	0	26
1974	0	0	2	6	8	9	9	0	34
TOTAL	0	0	47	81	100	106	106	0	440

TABLE 44 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL
MINIMUM RELEASE 5000 CFS MARCH THROUGH JUNE, ZERO
REMAINDER OF YEAR, BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	0	0	0	0	0	0	0
1962	0	0	0	20	31	31	30	31	143
1963	0	0	0	0	0	0	0	0	0
1964	0	0	0	15	31	31	30	31	138
1965	0	0	0	23	31	31	30	31	146
1966	0	0	0	2	9	19	18	30	78
1967	0	0	0	0	1	7	16	7	31
1968	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0
1971	0	0	0	10	31	31	30	31	133
1972	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	70	134	150	154	161	669

TABLE 45 -- MINIMUM POOL ELEVATION
MINIMUM RELEASE 5000 CFS MARCH THROUGH JUNE, ZERO RE-
MAINDER OF YEAR, BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1961	107.23	107.23	106.67	105.50	105.69	105.85	105.45	106.72
1962	106.09	107.23	102.66	92.05	90.48	90.41	89.67	86.68
1963	107.23	106.44	105.83	103.45	101.95	101.60	100.98	100.65
1964	106.45	107.23	105.49	92.97	91.67	91.34	90.47	91.05
1965	104.91	103.05	101.58	89.70	88.88	87.60	86.64	84.42
1966	107.23	105.90	106.09	99.10	97.88	97.21	97.12	96.38
1967	106.63	106.99	106.37	102.22	98.94	98.36	98.00	96.99
1968	102.68	105.50	104.91	105.04	103.38	104.76	104.63	102.91
1969	101.68	106.36	104.55	100.81	99.66	100.13	101.44	101.29
1970	106.11	107.23	106.57	103.63	101.95	102.72	102.90	101.25
1971	107.23	105.73	103.48	96.31	94.93	95.55	93.14	92.01
1972	107.15	107.23	107.23	105.96	106.45	105.27	105.78	105.62
1973	106.87	105.99	105.43	106.12	104.07	102.64	104.37	104.48
1974	106.57	107.23	106.13	100.94	103.19	102.24	100.06	99.93

TABLE 46

POWER GENERATION LOSS, MINIMUM RELEASE 5000 CFS
MARCH THRU JUNE, ZERO REMAINDER OF YEAR
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	PRIOR TO REACHING ELEVATION 99.2			GENERATION LOST AFTER REACHING 99.2
	PEAKING GENERATION LOST (CFS DAYS)	TOTAL GENERATION POSSIBLE (CFS DAYS)	% LOST	
1961	329639	2564818	12.9	0
1962	291527	1273228	22.9	1144501
1963	551792	2786970	19.8	0
1964	245961	931119	26.4	620432
1965	376532	2078237	18.1	779097
1966	382259	1863198	20.5	616155
1967	340092	1957368	17.4	1596427
1968	492644	3252885	15.1	0
1969	608562	3794011	16.0	0
1970	482679	3899117	12.4	0
1971	291327	1618501	18.0	1423835
1972	217340	2396525	9.1	0
1973	351747	3726378	9.4	0
1974	499421	4103977	12.2	0
TOTAL	5461522	36246332	15.1	6180447

TABLE 47 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL
MINIMUM RELEASE 2500 CFS YEAR ROUND
BALTIMORE WITHDRAWAL 100 MGD (155 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	1	0	5	8	9	0	23
1962	0	0	1	9	9	8	10	0	37
1963	0	0	0	2	8	9	9	0	28
1964	0	0	2	8	8	10	8	0	36
1965	0	0	10	8	9	9	8	0	44
1966	0	0	4	5	10	8	8	0	35
1967	0	0	2	2	10	8	9	0	31
1968	0	0	2	5	8	9	9	0	33
1969	0	0	5	7	8	10	8	0	38
1970	0	0	1	2	6	9	8	0	26
1971	0	0	9	8	9	9	8	0	43
1972	0	0	0	3	0	5	9	0	17
1973	0	0	7	1	7	8	10	0	33
1974	0	0	2	3	5	9	9	0	28
TOTAL	0	0	46	63	102	119	122	0	452

TABLE 48 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL
MINIMUM RELEASE 2500 CFS YEAR ROUND
BALTIMORE WITHDRAWAL 100 MGD (155 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	0	0	0	0	0	26	26
1962	0	0	0	0	25	31	30	31	117
1963	0	0	0	0	0	17	30	31	78
1964	0	0	0	0	24	31	30	31	116
1965	0	0	0	7	31	31	30	31	130
1966	0	0	0	0	5	31	30	31	97
1967	0	0	0	0	2	19	30	31	82
1968	0	0	0	0	0	9	30	31	70
1969	0	0	0	0	1	3	29	31	64
1970	0	0	0	0	0	0	13	31	44
1971	0	0	0	0	26	31	30	31	118
1972	0	0	0	0	0	0	9	31	40
1973	0	0	0	0	0	3	19	30	52
1974	0	0	0	0	0	0	22	31	53
TOTAL	0	0	0	7	114	206	332	428	1087

TABLE 49 -- MINIMUM POOL ELEVATION
MINIMUM RELEASE 2500 CFS YEAR ROUND
BALTIMORE WITHDRAWAL 100 MGD (155 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1961	107.23	107.23	106.67	105.52	103.43	102.61	100.28	93.98
1962	106.10	107.23	104.78	100.59	93.87	89.10	82.04	74.59
1963	107.23	106.44	105.86	105.36	100.85	95.76	89.35	81.15
1964	106.42	107.23	105.43	100.01	94.28	88.27	77.73	66.47
1965	104.93	103.05	102.17	97.33	91.80	83.46	73.64	60.40
1966	107.23	105.92	106.11	103.05	96.56	91.38	87.14	74.73
1967	106.56	106.99	106.36	104.84	98.51	95.30	92.32	87.62
1968	104.05	105.52	105.19	105.07	102.30	97.73	93.61	86.52
1969	104.06	106.35	104.54	103.12	99.06	98.10	93.34	88.74
1970	106.13	107.23	106.59	104.90	103.50	100.28	96.76	91.44
1971	107.23	105.74	103.49	100.92	95.36	92.70	85.41	75.02
1972	107.14	107.23	107.23	105.99	106.48	102.71	98.06	92.64
1973	106.89	105.98	105.41	106.15	102.09	98.69	96.47	92.25
1974	106.56	107.23	106.16	103.86	103.71	100.20	94.87	90.22

TABLE 50

POWER GENERATION LOSS, MINIMUM RELEASE 2500 CFS
YEAR ROUND, BALTIMORE WITHDRAWAL 100 MGD (155 CFS)

YEAR	PRIOR TO REACHING ELEVATION 99.2			GENERATION LOST AFTER REACHING 99.2
	PEAKING GENERATION LOST (CFS DAYS)	TOTAL GENERATION POSSIBLE (CFS DAYS)	% LOST	
1961	395914	2438630	16.2	126188
1962	215090	1455774	14.8	961955
1963	368362	2498195	14.7	288775
1964	187633	1105595	17.0	445956
1965	238150	2245301	10.6	612033
1966	275756	2017103	13.7	462250
1967	242797	1933087	12.6	1620708
1968	351647	2549021	13.8	703864
1969	350093	2688022	13.0	1105989
1970	425203	3190133	13.3	708984
1971	205153	1811079	11.3	1231257
1972	266165	2096128	12.7	300397
1973	277972	2579676	10.8	1146702
1974	403411	3171285	12.7	932692
TOTAL	4203346	31779029	13.2	10647750

TABLE 51 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL
MINIMUM RELEASE 5000 CFS YEAR ROUND, BALTIMORE
WITHDRAWAL 100 MGD (155 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	1	2	8	8	9	0	28
1962	0	0	2	9	9	8	10	0	38
1963	0	0	0	4	8	9	9	0	30
1964	0	0	2	8	8	10	8	0	36
1965	0	0	10	8	9	9	8	0	44
1966	0	0	4	6	10	8	8	0	36
1967	0	0	2	5	10	8	9	0	34
1968	0	0	2	5	8	9	9	0	33
1969	0	0	5	8	8	10	8	0	39
1970	0	0	1	6	8	10	8	0	33
1971	0	0	9	8	9	9	8	0	43
1972	0	0	0	3	0	8	9	0	20
1973	0	0	7	1	7	8	10	0	33
1974	0	0	2	6	8	9	9	0	34
TOTAL	0	0	47	79	110	123	122	0	481

TABLE 52 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL
MINIMUM RELEASE 5000 CFS YEAR ROUND, BALTIMORE
WITHDRAWAL 100 MGD (155 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	0	0	0	20	30	31	81
1962	0	0	0	19	31	31	30	31	142
1963	0	0	0	0	18	31	30	31	110
1964	0	0	0	15	31	31	30	31	138
1965	0	0	0	22	31	31	30	31	145
1966	0	0	0	0	30	31	30	31	122
1967	0	0	0	0	24	31	30	31	116
1968	0	0	0	0	3	31	30	31	95
1969	0	0	0	0	19	31	30	31	111
1970	0	0	0	0	0	26	30	31	87
1971	0	0	0	8	31	31	30	31	131
1972	0	0	0	0	0	4	30	31	65
1973	0	0	0	0	2	31	30	31	94
1974	0	0	0	0	1	29	30	31	91
TOTAL	0	0	0	64	221	389	420	434	1528

TABLE 53 -- MINIMUM ELEVATION
MINIMUM RELEASE 5000 CFS YEAR ROUND
BALTIMORE WITHDRAWAL 100 MGD (155 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1961	107.23	107.23	106.67	105.52	99.50	93.79	83.92	43.18
1962	106.10	107.23	102.84	92.30	68.26	-8888.00	-8888.00	-8888.00
1963	107.23	106.44	105.86	103.58	92.69	75.99	-8888.00	-8888.00
1964	106.42	107.23	105.43	93.13	78.77	-8888.00	-8888.00	-8888.00
1965	104.93	103.05	101.73	89.95	63.47	-8888.00	-8888.00	-8888.00
1966	107.23	105.92	106.11	99.28	81.71	42.19	-8888.00	-8888.00
1967	106.56	106.99	106.36	102.38	90.49	82.47	66.81	31.27
1968	102.71	105.52	104.99	105.07	98.45	87.25	71.16	-8888.00
1969	101.61	106.35	104.54	100.95	92.44	86.72	65.51	-8888.00
1970	106.13	107.23	106.59	103.67	99.73	89.02	75.68	54.73
1971	107.23	105.74	103.49	96.63	84.67	71.08	-8888.00	-8888.00
1972	107.14	107.23	107.23	105.99	106.48	97.53	86.35	63.68
1973	106.89	105.98	105.41	106.15	98.34	90.75	82.92	58.85
1974	106.56	107.23	106.16	101.15	98.27	89.94	77.50	46.11

dicates that the pool is drawn down below elevation 30 approximately, which means that the storage is completely exhausted. Note that the number of deficits below elevation 99.2 is 1528 and the storage is completely depleted in August for three years, in September for six years, and in October for eight years.

The amount of power generation lost is summarized in Table 54.

6) Minimum Release 5,000 cfs Year Round, Except When Inflow is Less Than 5,000 cfs, Release Net Inflow, Baltimore Withdrawal 250 mgd (388 cfs).

The number of deficits below elevation 107.2 and 99.2 are shown in Tables 55 and 56, respectively. Minimum pool elevations are shown in Table 57. Note that there are 1538 days on which the pool is below elevation 99.2, and that the storage is completely depleted in September for one year and October for two years.

Power generation lost is summarized in Table 58.

7) Minimum Release 15,000 cfs March through May, 5,000 cfs Remainder of Year, No Baltimore Withdrawal.

The number of deficits below elevation 107.2 and 99.2 are shown in Tables 59 and 60, respectively. Minimum pool elevations are shown in Table 61. Note there are 1640 days on which the pool elevation is below 99.2, and that the storage is completely depleted in July for two years, August for three years, September for six years and October for eight years.

Peaking power generation lost is summarized in Table 62.

The following cases are in addition to the cases specifically requested by Maryland. These extra cases were run because it was convenient to include them in a computer job, due to the structure of the program. The amount of peaking power generation lost was not computed for these extra cases because of time and cost constraints. Such computations could be made if deemed necessary.

8) Minimum Release 5,000 cfs, Except When Inflow is Less Than 5,000 cfs, Release Net Inflow, Baltimore Withdrawal 100 mgd.

The number of deficits below elevations 107.2 and 99.2 are shown in Tables 63 and 64, respectively. Minimum pool elevations are shown in Table 65. Note that there are 1528

TABLE 54

POWER GENERATION LOSS, MINIMUM RELEASE 5000 CFS
YEAR ROUND, BALTIMORE WITHDRAWAL 100 MGD (155 CFS)

YEAR	PRIOR TO REACHING ELEVATION 99.2			GENERATION LOST AFTER REACHING 99.2
	PEAKING GENERATION LOST (CFS DAYS)	TOTAL GENERATION POSSIBLE (CFS DAYS)	% LOST	
1961	470257	1975186	23.8	589632
1962	285190	1273711	22.4	1144018
1963	534766	2322420	23.0	464550
1964	235985	931119	25.3	620432
1965	372210	2123775	17.5	733559
1966	394002	1915836	20.6	563517
1967	338850	1624646	20.9	1929149
1968	542700	2398687	22.6	854198
1969	583909	2535821	23.0	1258190
1970	585730	2832397	20.7	1066720
1971	284990	1641466	17.4	1400870
1972	371297	1893131	19.6	503394
1973	427753	2347909	18.2	1378469
1974	565166	2778914	20.3	1325063
TOTAL	5992806	28595018	21.0	13831761

TABLE 58

POWER GENERATION LOSS, MINIMUM RELEASE 5000 CFS
EXCEPT WHEN INFLOW LESS THAN 5000 CFS
RELEASE NET INFLOW, BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	PRIOR TO REACHING ELEVATION 99.2			GENERATION LOST AFTER REACHING 99.2
	PEAKING GENERATION LOST (CFS DAYS)	TOTAL GENERATION POSSIBLE (CFS DAYS)	% LOST	
1961	484902	1958156	24.8	606662
1962	291527	1273228	22.9	1144501
1963	557502	2322420	24.0	464550
1964	245961	931119	26.4	620432
1965	376532	2078237	18.1	779097
1966	382259	1863198	20.5	616155
1967	353234	1824646	21.7	1929149
1968	565900	2398687	23.6	854198
1969	608733	2535821	24.0	1258190
1970	610786	2832397	21.6	1066720
1971	291327	1618501	18.0	1423835
1972	381766	1892655	20.2	503870
1973	446081	2347909	19.0	1378469
1974	589294	2778914	21.2	1325063
TOTAL	6185804	28455888	21.7	13970891

TABLE 55 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL, MINIMUM RELEASE 5000 CFS YEAR ROUND EXCEPT WHEN INFLOW IS LESS THAN 5000 CFS RELEASE NET INFLOW, BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	1	2	8	8	9	0	28
1962	0	0	2	9	9	8	10	0	38
1963	0	0	0	4	8	9	9	0	30
1964	0	0	2	8	8	10	8	0	36
1965	0	0	10	8	9	9	8	0	44
1966	0	0	4	6	10	8	8	0	36
1967	0	0	2	6	10	8	9	0	35
1968	0	0	2	5	8	9	9	0	33
1969	0	0	5	8	8	10	8	0	39
1970	0	0	1	7	8	10	8	0	34
1971	0	0	9	8	9	9	9	0	43
1972	0	0	0	3	0	8	9	0	20
1973	0	0	7	1	7	8	10	0	33
1974	0	0	2	6	8	9	9	0	34
TOTAL	0	0	47	81	110	123	122	0	483

TABLE 56 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL, MINIMUM RELEASE 5000 CFS YEAR ROUND EXCEPT WHEN INFLOW IS LESS THAN 5000 CFS RELEASE NET INFLOW, BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	0	0	0	21	30	31	82
1962	0	0	0	20	31	31	30	31	143
1963	0	0	0	0	18	31	30	31	110
1964	0	0	0	15	31	31	30	31	138
1965	0	0	0	23	31	31	30	31	146
1966	0	0	0	2	30	31	30	31	124
1967	0	0	0	0	25	31	30	31	117
1968	0	0	0	0	4	31	30	31	96
1969	0	0	0	0	19	31	30	31	111
1970	0	0	0	0	0	26	30	31	87
1971	0	0	0	10	31	31	30	31	133
1972	0	0	0	0	0	5	30	31	66
1973	0	0	0	0	2	31	30	31	94
1974	0	0	0	0	1	29	30	31	91
TOTAL	0	0	0	70	223	391	420	434	1538

TABLE 57 -- MINIMUM ELEVATION
MINIMUM RELEASE 5000 CFS YEAR ROUND EXCEPT WHEN INFLOW IS LESS THAN 5000 CFS RELEASE NET INFLOW, BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1961	107.23	107.23	106.67	105.50	99.30	93.51	84.39	82.96
1962	106.09	107.23	102.66	92.05	89.84	89.84	86.97	75.73
1963	107.23	106.44	105.83	103.45	92.53	87.88	86.20	86.20
1964	106.45	107.23	105.49	92.97	80.26	79.39	79.39	79.39
1965	104.91	103.05	101.58	89.70	89.06	86.63	86.36	62.88
1966	107.23	105.90	106.09	99.10	94.01	94.01	92.51	81.68
1967	106.63	106.99	106.37	102.22	90.16	91.70	65.43	-8888.00
1968	102.68	105.50	104.91	105.04	99.33	83.78	83.72	63.83
1969	101.68	106.36	104.55	100.81	92.19	86.25	72.57	64.76
1970	106.11	107.23	106.57	103.63	99.50	88.60	75.00	53.50
1971	107.23	105.73	103.48	96.31	84.20	71.76	-8888.00	-8888.00
1972	107.15	107.23	107.23	105.96	106.45	97.37	86.14	63.10
1973	106.87	105.99	105.43	106.12	98.21	90.54	82.62	56.89
1974	106.57	107.23	106.13	100.94	93.03	89.62	75.38	41.76

TABLE 59 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL, MINIMUM RELEASE 15000 CFS MARCH THROUGH MAY, 5000 CFS REMAINDER OF YEAR, NO BALTIMORE WITHDRAWAL

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	1	0	8	8	9	0	26
1962	0	0	4	9	9	8	10	0	40
1963	0	0	8	10	8	9	9	0	44
1964	0	0	4	8	8	10	8	0	38
1965	0	0	10	8	9	9	8	0	44
1966	0	0	4	6	10	8	8	0	36
1967	0	0	2	5	10	8	9	0	34
1968	0	0	8	5	8	9	9	0	39
1969	0	0	6	9	8	10	8	0	41
1970	0	0	1	6	8	10	8	0	33
1971	0	0	9	8	9	9	8	0	43
1972	0	0	0	3	0	7	9	0	19
1973	0	0	7	1	7	8	10	0	33
1974	0	0	2	6	8	9	9	0	34
TOTAL	0	0	66	84	110	122	122	0	504

TABLE 60 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL, MINIMUM RELEASE 15000 CFS MARCH THROUGH MAY, 5000 CFS REMAINDER OF YEAR, NO BALTIMORE WITHDRAWAL

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	0	0	0	20	30	31	81
1962	0	0	8	30	31	31	30	31	161
1963	0	0	0	0	25	31	30	31	117
1964	0	0	1	30	31	31	30	31	154
1965	0	0	6	30	31	31	30	31	159
1966	0	0	0	0	30	31	30	31	122
1967	0	0	0	0	23	31	30	31	115
1968	10	0	24	0	2	31	30	31	128
1969	17	0	0	3	29	31	30	31	141
1970	0	0	0	0	0	25	30	31	86
1971	0	0	0	12	31	31	30	31	135
1972	0	0	0	0	0	3	30	31	64
1973	0	0	0	0	2	31	30	31	94
1974	0	0	0	0	1	27	30	31	89
TOTAL	27	0	39	105	236	385	420	434	1646

TABLE 61 -- MINIMUM ELEVATIONS MINIMUM RELEASE 15000 CFS MARCH THROUGH MAY, 5000 CFS REMAINDER OF YEAR, NO BALTIMORE WITHDRAWAL

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1961	107.23	107.23	106.67	105.54	99.63	93.97	84.31	46.97
1962	106.10	107.23	90.94	76.77	-8888.00	-8888.00	-8888.00	-8888.00
1963	101.85	105.77	101.84	101.51	90.34	71.73	-8888.00	-8888.00
1964	104.12	107.23	96.13	81.79	54.72	-8888.00	-8888.00	-8888.00
1965	104.94	103.05	91.05	74.73	-8888.00	-8888.00	-8888.00	-8888.00
1966	107.23	102.80	106.12	93.71	83.02	50.53	-8888.00	-8888.00
1967	103.97	106.98	106.36	102.63	90.92	83.28	68.28	36.59
1968	92.86	101.53	92.10	105.08	98.53	87.43	71.70	-8888.00
1969	80.63	106.33	103.50	98.11	89.51	82.90	57.71	-8888.00
1970	106.14	107.23	106.61	103.79	100.09	89.52	76.55	56.33
1971	107.23	105.74	103.49	95.36	82.78	63.28	-8888.00	-8888.00
1972	107.12	107.23	107.23	106.00	106.49	97.63	86.49	64.07
1973	105.43	105.97	105.40	106.16	98.42	90.91	83.13	60.23
1974	106.56	107.23	106.17	101.52	98.70	90.41	78.80	50.28

TABLE 62

POWER GENERATION LOSS, MINIMUM RELEASE 15000 CFS
MARCH THRU MAY, 5000 CFS REMAINDER OF YEAR
ZERO BALTIMORE WITHDRAWAL

YEAR	PRIOR TO REACHING ELEVATION 99.2			GENERATION LOST AFTER REACHING 99.2
	PEAKING GENERATION LOST (CFS DAYS)	TOTAL GENERATION POSSIBLE (CFS DAYS)	% LOST	
1961	611132	1975186	30.9	589632
1962	521010	1080231	48.2	1337498
1963	1027872	2273984	45.2	512986
1964	429220	747543	57.4	804008
1965	826910	1927281	42.9	930053
1966	787202	1915836	41.1	563517
1967	598752	1643112	36.4	1910683
1968	137610	129642	106.1	3123243
1969	137610	127711	107.8	3666300
1970	993350	2832397	35.1	1066720
1971	613430	1592415	38.5	1449921
1972	467406	1893131	24.7	503394
1973	660808	2347909	28.1	1378469
1974	1003406	2778914	36.1	1325063
TOTAL	8815718	23265292	37.9	19161487

TABLE 63 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL, MINIMUM RELEASE 5000 CFS EXCEPT WHEN INFLOW IS LESS THAN 5000 CFS RELEASE NET INFLOW, BALTIMORE WITHDRAWAL 100 MGD (155 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	1	2	8	8	9	0	28
1962	0	0	2	9	9	8	10	0	38
1963	0	0	0	4	8	9	9	0	30
1964	0	0	2	8	8	10	8	0	36
1965	0	0	10	8	9	9	8	0	44
1966	0	0	4	6	10	8	8	0	36
1967	0	0	2	5	10	8	9	0	34
1968	0	0	2	5	8	9	9	0	33
1969	0	0	5	8	8	10	8	0	39
1970	0	0	1	6	8	10	8	0	33
1971	0	0	9	8	9	9	8	0	43
1972	0	0	0	3	0	8	9	0	20
1973	0	0	7	1	7	8	10	0	33
1974	0	0	2	6	8	9	9	0	34
TOTAL	0	0	47	79	110	123	122	0	481

TABLE 64 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL, MINIMUM RELEASE 5000 CFS EXCEPT WHEN INFLOW IS LESS THAN 5000 CFS RELEASE NET INFLOW, BALTIMORE WITHDRAWAL 100 MGD (155 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	0	0	0	20	30	31	81
1962	0	0	0	19	31	31	30	31	142
1963	0	0	0	0	18	31	30	31	110
1964	0	0	0	15	31	31	30	31	138
1965	0	0	0	22	31	31	30	31	145
1966	0	0	0	0	30	31	30	31	122
1967	0	0	0	0	24	31	30	31	116
1968	0	0	0	0	3	31	30	31	95
1969	0	0	0	0	19	31	30	31	111
1970	0	0	0	0	0	26	30	31	87
1971	0	0	0	8	31	31	30	31	131
1972	0	0	0	0	0	4	30	31	65
1973	0	0	0	0	2	31	30	31	94
1974	0	0	0	0	1	29	30	31	91
TOTAL	0	0	0	64	221	389	420	434	1528

TABLE 65 -- MINIMUM POOL ELEVATION MINIMUM RELEASE 5000 CFS EXCEPT WHEN INFLOW IS LESS THAN 5000 CFS, RELEASE INFLOW, BALTIMORE WITHDRAWAL 100 MGD (155 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1961	107.23	107.23	106.67	105.52	99.50	93.79	85.01	83.56
1962	106.10	107.23	102.84	92.30	90.13	89.53	85.78	73.82
1963	107.23	106.44	105.86	103.58	92.69	87.37	85.57	95.57
1964	106.42	107.23	105.43	93.13	80.54	79.84	79.84	79.84
1965	104.93	103.05	101.73	89.95	89.31	86.08	85.68	61.60
1966	107.23	105.92	106.11	99.28	93.20	92.69	91.23	78.55
1967	106.56	106.99	106.36	102.38	90.49	82.47	66.81	31.27
1968	102.71	105.52	104.99	105.07	98.45	88.46	82.05	51.51
1969	101.61	106.35	104.54	100.95	92.44	86.72	71.98	63.36
1970	106.13	107.23	106.59	103.67	99.73	89.02	75.68	54.73
1971	107.23	105.74	103.49	96.63	84.67	72.20	-8888.00	-8888.00
1972	107.14	107.23	107.23	105.99	106.48	97.53	86.35	63.69
1973	106.89	105.98	105.41	106.15	98.34	90.75	82.92	58.65
1974	106.56	107.23	106.16	101.15	93.27	89.94	77.50	46.11

days when the pool is below elevation 99.2, and that the storage is completely depleted in 1971 for the months of September and October.

9) Minimum Release 5,000 cfs Year Round, Baltimore Withdrawal 250 mgd (388 cfs).

The number of deficits below elevations 107.2 and 99.2 are shown in Tables 66 and 67, respectively. Minimum pool elevations are shown in Table 68. Note that there are 1528 days on which the pool elevation is below 99.2, and the storage is exhausted in August for four years, in September for six years and in October for nine years.

10) Minimum Release 5,000 cfs March through June, Otherwise Release Net Inflow, Baltimore Withdrawal 250 mgd (388 cfs).

The number of deficits below elevations 107.2 and 99.2 are shown in Tables 69 and 70, respectively. Minimum pool elevations are shown in Table 71. Note that there are 1546 days on which the pool is below 99.2 and the storage is completely depleted in September for 1971 and in October for 1967, 1971 and 1974.

11) Minimum Release 15,000 cfs March through May; 5,000 cfs Remainder of Year Except if Inflow is Less Than 5,000 cfs, Release Net Inflow, Zero Baltimore Withdrawal.

The number of deficits below elevations 107.2 and 99.2 are shown in Tables 72 and 73, respectively. Minimum pool elevations are shown in Table 74. Note there are 1646 days on which pool elevation is below 99.2 and the storage is completely exhausted in September 1971 and October 1962, 1965 and 1971.

12) Minimum Release 2,500 cfs Except When Inflow is Less Than 2,500 cfs, Release Net Inflow; Zero Baltimore Withdrawal.

The number of deficits below elevations 107.2 and 99.2 are shown in Tables 75 and 76, respectively. Minimum pool elevations are shown in Table 77. Note there are 1063 days on which the pool elevation is below 99.2 and the minimum pool elevation is 62.32 ft. msl in October 1965.

13) Minimum Release 15,000 cfs March through May; 5,000 cfs Remainder of Year Except When Inflow is Less Than 5,000 cfs, Release Net Inflow, Baltimore Withdrawal 250 mgd (388 cfs).

TABLE 66 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL,
MINIMUM RELEASE 5000 CFS YEAR ROUND
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	1	2	8	8	9	0	28
1962	0	0	2	9	9	8	10	0	38
1963	0	0	0	4	8	9	9	0	30
1964	0	0	2	8	8	10	8	0	36
1965	0	0	10	8	9	9	8	0	44
1966	0	0	4	6	10	8	8	0	36
1967	0	0	2	6	10	8	9	0	35
1968	0	0	2	5	8	9	9	0	33
1969	0	0	5	8	8	10	8	0	39
1970	0	0	1	7	8	10	8	0	34
1971	0	0	9	8	9	9	8	0	43
1972	0	0	0	3	0	8	9	0	20
1973	0	0	7	1	7	8	10	0	33
1974	0	0	2	6	8	9	9	0	34
TOTAL	0	0	47	81	110	123	122	0	483

TABLE 67 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL,
MINIMUM RELEASE 5000 CFS YEAR ROUND
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	0	0	0	21	30	31	82
1962	0	0	0	20	31	31	30	31	143
1963	0	0	0	0	18	31	30	31	110
1964	0	0	0	15	31	31	30	31	138
1965	0	0	0	23	31	31	30	31	146
1966	0	0	0	2	30	31	30	31	124
1967	0	0	0	0	25	31	30	31	117
1968	0	0	0	0	4	31	30	31	96
1969	0	0	0	0	19	31	30	31	111
1970	0	0	0	0	0	26	30	31	87
1971	0	0	0	10	31	31	30	31	133
1972	0	0	0	0	0	5	30	31	66
1973	0	0	0	0	2	31	30	31	94
1974	0	0	0	0	1	29	30	31	91
TOTAL	0	0	0	70	223	391	420	434	1538

TABLE 68 -- MINIMUM POOL ELEVATION
MINIMUM RELEASE 5000 CFS YEAR ROUND
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1961	107.23	107.23	106.67	105.50	99.30	93.51	83.24	34.83
1962	106.09	107.23	102.66	92.05	65.65	-8888.00	-8888.00	-8888.00
1963	107.23	106.44	105.83	103.45	92.53	74.72	-8888.00	-8888.00
1964	106.45	107.23	105.49	92.97	78.13	-8888.00	-8888.00	-8888.00
1965	104.91	103.05	101.58	89.70	59.88	-8888.00	-8888.00	-8888.00
1966	107.23	105.90	106.09	99.10	80.18	-8888.00	-8888.00	-8888.00
1967	106.63	106.99	106.37	102.22	90.16	81.70	65.43	-8888.00
1968	102.63	105.50	104.91	105.04	98.33	86.98	70.36	-8888.00
1969	101.68	106.36	104.55	100.81	92.19	86.25	63.90	-8888.00
1970	106.11	107.23	106.57	103.63	99.50	88.60	75.00	53.50
1971	107.23	105.73	103.48	96.31	84.20	70.24	-8888.00	-8888.00
1972	107.15	107.23	107.23	105.96	106.45	97.37	86.14	63.10
1973	106.87	105.99	105.43	106.12	98.21	90.54	82.62	56.89
1974	106.57	107.23	106.13	100.94	98.03	89.62	76.38	41.76

TABLE 69 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL
MINIMUM RELEASE 5000 CFS MARCH THROUGH JUNE, OTHERWISE RELEASE NET INFLOW, BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	1	2	8	8	9	0	28
1962	0	0	2	9	9	8	10	0	38
1963	0	0	0	4	8	9	9	0	30
1964	0	0	2	8	8	10	8	0	36
1965	0	0	10	8	9	9	8	0	44
1966	0	0	4	6	10	8	8	0	36
1967	0	0	2	6	10	8	9	0	35
1968	0	0	2	5	8	9	9	0	33
1969	0	0	5	8	8	10	8	0	39
1970	0	0	1	7	8	10	8	0	34
1971	0	0	9	8	9	9	8	0	43
1972	0	0	0	3	0	8	9	0	20
1973	0	0	7	1	7	8	10	0	33
1974	0	0	2	6	8	9	9	0	34
TOTAL	0	0	47	81	110	123	122	0	483

TABLE 70 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL
MINIMUM RELEASE 5000 CFS MARCH THROUGH JUNE, OTHERWISE RELEASE NET INFLOW, BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	0	0	1	23	30	31	85
1962	0	0	0	20	31	31	30	31	143
1963	0	0	0	0	18	31	30	31	110
1964	0	0	0	15	31	31	30	31	138
1965	0	0	0	23	31	31	30	31	146
1966	0	0	0	2	30	31	30	31	124
1967	0	0	0	0	26	31	30	31	118
1968	0	0	0	0	4	31	30	31	96
1969	0	0	0	0	20	31	30	31	112
1970	0	0	0	0	0	27	30	31	88
1971	0	0	0	10	31	31	30	31	133
1972	0	0	0	0	0	5	30	31	66
1973	0	0	0	0	2	31	30	31	94
1974	0	0	0	0	2	30	30	31	93
TOTAL	0	0	0	70	227	395	420	434	1546

TABLE 71 -- MINIMUM ELEVATION
MINIMUM RELEASE 5000 CFS MARCH THROUGH JUNE, OTHERWISE RELEASE NET INFLOW, BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1961	107.23	107.23	106.67	105.50	98.89	92.68	82.46	81.03
1962	106.09	107.23	102.66	92.08	89.87	89.87	86.95	75.07
1963	107.23	106.44	105.83	103.45	92.08	87.29	87.29	87.32
1964	106.45	107.23	105.49	92.97	80.32	79.93	79.93	79.93
1965	104.91	103.05	101.58	89.70	89.06	86.63	86.36	61.51
1966	107.23	105.90	106.09	99.10	95.15	95.15	94.10	86.31
1967	106.63	106.99	106.37	102.22	89.73	80.62	62.43	-8888.00
1968	102.68	105.50	104.91	105.04	98.02	89.90	83.43	71.97
1969	101.68	106.36	104.55	100.81	91.87	85.27	70.62	61.51
1970	106.11	107.23	106.57	103.63	99.34	87.83	72.75	47.74
1971	107.23	105.73	103.48	96.31	83.58	70.22	-8888.00	-8888.00
1972	107.15	107.23	107.23	105.96	106.45	96.96	84.88	59.36
1973	106.87	105.99	105.43	106.12	97.90	89.91	81.23	51.47
1974	106.57	107.23	106.13	100.94	97.77	88.97	74.54	-8888.00

TABLE 72 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL, MINIMUM RELEASE 15000 CFS MARCH THROUGH MAY, 5000 CFS REMAINDER OF YEAR EXCEPT WHEN INFLOW LESS THAN 5000 CFS RELEASE NET INFLOW, ZERO BALTIMORE WITHDRAWAL

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	1	0	8	8	9	0	26
1962	0	0	4	9	9	8	10	0	40
1963	0	0	8	10	8	9	9	0	44
1964	0	0	4	8	8	10	8	0	38
1965	0	0	10	8	9	9	8	0	44
1966	0	0	4	6	10	8	8	0	36
1967	0	0	2	5	10	8	9	0	34
1968	0	0	8	5	8	9	9	0	39
1969	0	0	6	9	8	10	8	0	41
1970	0	0	1	6	8	10	8	0	33
1971	0	0	9	8	9	9	8	0	43
1972	0	0	0	3	0	7	9	0	19
1973	0	0	7	1	7	8	10	0	33
1974	0	0	2	6	8	9	9	0	34
TOTAL	0	0	66	84	110	122	122	0	504

TABLE 73 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL, MINIMUM RELEASE 15000 CFS MARCH THROUGH MAY; 5000 CFS REMAINDER OF YEAR EXCEPT WHEN INFLOW LESS THAN 5000 CFS RELEASE NET INFLOW, ZERO BALTIMORE WITHDRAWAL

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	0	0	0	20	30	31	81
1962	0	0	8	30	31	31	30	31	161
1963	0	0	0	0	25	31	30	31	117
1964	0	0	1	30	31	31	30	31	154
1965	0	0	6	30	31	31	30	31	159
1966	0	0	0	0	30	31	30	31	122
1967	0	0	0	0	23	31	30	31	115
1968	10	0	24	0	2	31	30	31	128
1969	17	0	0	3	29	31	30	31	141
1970	0	0	0	0	0	25	30	31	86
1971	0	0	0	12	31	31	30	31	135
1972	0	0	0	0	0	3	30	31	64
1973	0	0	0	0	2	31	30	31	94
1974	0	0	0	0	1	27	30	31	89
TOTAL	27	0	39	105	236	385	420	434	1646

TABLE 74 -- MINIMUM POOL ELEVATION MINIMUM RELEASE 15000 CFS MARCH THROUGH MAY; 5000 CFS REMAINDER OF YEAR, EXCEPT WHEN INFLOW LESS THAN 5000 CFS RELEASE NET INFLOW, ZERO BALTIMORE WITHDRAWAL

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1961	107.23	107.23	106.67	105.54	99.63	93.97	85.36	83.90
1962	106.10	107.23	90.94	76.77	72.56	70.84	61.81	-8888.00
1963	101.85	105.77	101.84	101.51	90.34	84.37	81.93	81.93
1964	104.12	107.23	96.13	81.79	57.72	49.81	49.81	49.81
1965	104.94	103.05	91.05	74.73	72.30	64.63	63.78	-8888.00
1966	107.23	102.80	106.12	99.71	93.72	93.27	91.88	78.71
1967	103.97	106.98	106.36	102.63	90.92	83.28	63.23	36.59
1968	92.86	101.53	92.10	105.08	98.53	88.01	81.11	48.69
1969	80.63	106.33	103.50	98.11	69.51	82.90	65.12	53.91
1970	106.14	107.23	106.61	103.79	100.09	89.52	76.55	56.33
1971	107.23	105.74	103.49	95.36	82.78	68.28	-8888.00	-8888.00
1972	107.12	107.23	107.23	106.00	106.49	97.63	86.49	64.07
1973	105.43	105.97	105.40	106.16	98.42	90.91	83.13	60.23
1974	106.56	107.23	106.17	101.52	98.70	90.41	78.80	50.28

TABLE 75 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL MINIMUM RELEASE 2500 CFS EXCEPT WHEN INFLOW LESS THAN 2500 CFS RELEASE NET INFLOW, ZERO BALTIMORE WITHDRAWAL

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	1	0	5	8	9	0	23
1962	0	0	1	9	9	8	10	0	37
1963	0	0	0	2	8	9	9	0	28
1964	0	0	2	8	8	10	8	0	36
1965	0	0	10	8	9	9	8	0	44
1966	0	0	4	5	10	8	8	0	35
1967	0	0	2	1	10	8	9	0	30
1968	0	0	2	5	8	9	9	0	33
1969	0	0	5	7	8	10	8	0	38
1970	0	0	1	2	5	9	8	0	25
1971	0	0	9	8	9	9	8	0	43
1972	0	0	0	3	0	5	9	0	17
1973	0	0	7	1	7	8	10	0	33
1974	0	0	2	3	5	9	9	0	28
TOTAL	0	0	46	62	101	119	122	0	450

TABLE 76 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL MINIMUM RELEASE 2500 CFS EXCEPT WHEN INFLOW LESS THAN 2500 CFS RELEASE NET INFLOW, ZERO BALTIMORE WITHDRAWAL

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	0	0	0	0	0	26	26
1962	0	0	0	0	20	31	30	31	112
1963	0	0	0	0	0	16	30	31	77
1964	0	0	0	0	21	31	30	31	113
1965	0	0	0	4	31	31	30	31	127
1966	0	0	0	0	4	31	30	31	96
1967	0	0	0	0	1	18	29	31	79
1968	0	0	0	0	0	9	30	31	70
1969	0	0	0	0	0	3	29	31	63
1970	0	0	0	0	0	0	12	31	43
1971	0	0	0	0	23	31	30	31	115
1972	0	0	0	0	0	0	9	31	40
1973	0	0	0	0	0	3	17	29	49
1974	0	0	0	0	0	0	22	31	53
TOTAL	0	0	0	4	100	204	328	427	1063

TABLE 77 -- MINIMUM ELEVATION MINIMUM RELEASE 2500 CFS EXCEPT WHEN INFLOW LESS THAN 2500 CFS RELEASE NET INFLOW, ZERO BALTIMORE WITHDRAWAL

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1961	107.23	107.23	106.67	105.54	103.38	102.54	100.30	94.05
1962	106.10	107.23	104.81	101.06	94.51	89.80	83.24	76.16
1963	107.23	106.44	105.87	105.38	101.10	96.09	89.77	86.21
1964	106.41	107.23	105.39	100.47	94.81	88.97	86.79	81.58
1965	104.94	103.05	102.19	97.87	92.43	84.60	75.06	62.32
1966	107.23	105.94	106.12	103.43	97.12	92.06	90.14	80.34
1967	106.52	106.98	106.36	105.09	98.84	95.74	92.72	88.04
1968	104.04	105.54	105.21	105.08	102.37	97.81	93.72	86.58
1969	104.01	106.33	104.54	103.25	99.21	98.26	93.58	88.98
1970	106.14	107.23	106.61	105.02	103.69	100.54	97.00	91.68
1971	107.23	105.74	103.49	101.14	95.75	93.11	85.98	75.77
1972	107.12	107.23	107.23	106.00	106.49	102.81	98.18	92.79
1973	106.90	105.97	105.40	106.16	102.12	98.75	96.58	92.61
1974	106.56	107.23	106.17	103.96	103.68	100.18	94.93	90.31

The number of deficits below elevations 107.2 and 99.2 are shown in Tables 78 and 79, respectively. The minimum pool elevations are shown in Table 80. Note there are 1678 days on which the pool elevation is below 99.2 and the storage is completely exhausted in September 1971 and in October in four years.

14) Minimum Release 2,500 cfs; Except When Inflow Less Than 2,500 cfs; Release Net Inflow; Baltimore Withdrawal 250 mgd.

The number of deficits below elevations 107.2 and 99.2 are shown in Tables 81 and 82, respectively. Minimum pool elevations are shown in Table 83. Note there are 1108 days on which the pool elevation is less than 99.2, and the minimum pool elevation is 59.13 ft. msl in October 1965.

c. Fixed Minimum Pool Elevation Compute Release

1) Target Elevation 102.0 ft. msl; Baltimore Withdrawal 100 cfs.

The number of deficits below elevations 107.2 and 102.0 are shown in Tables 84 and 85, respectively. Minimum pool elevations are shown in Table 86. Note that there are 16 days on which the minimum pool elevation is below the target elevation.

The average and range of daily flow releases are shown in Table 87 for each month and each year. Note the negative minimum releases in 1965 and that minimum releases of the order of 400 cfs are experienced in many months and in every year.

2) Target Elevation 99.2 ft. msl; Baltimore Withdrawal 100 cfs.

The number of deficits below elevations 107.2 and 99.2 are shown in Tables 88 and 89, respectively. The minimum pool elevations are shown in Table 90. Note that there are two days on which the pool elevation is below 99.2, and the minimum pool elevation is 98.98 in October 1965, which agrees with the results of the base case shown in Tables 33 and 34.

The average and range of daily flow releases are shown in Table 91 for each month of each year. There are no negative releases for this case, but minimum releases of the order of 400 cfs still occur in many months and in all years.

3) Target Elevation 107.2; Baltimore Withdrawal 100 cfs.

TABLE 78 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL, MINIMUM RELEASE 15000 CFS MARCH THROUGH MAY; 5000 CFS REMAINDER OF YEAR, EXCEPT WHEN INFLOW LESS THAN 5000 CFS RELEASE NET INFLOW, BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	1	2	8	8	9	0	28
1962	0	0	4	9	9	8	10	0	40
1963	0	0	8	10	8	9	9	0	44
1964	0	0	4	8	8	10	8	0	38
1965	0	0	10	8	9	9	8	0	44
1966	0	0	4	6	10	8	8	0	36
1967	0	0	2	5	10	8	9	0	34
1968	0	0	8	5	8	9	9	0	39
1969	0	0	6	9	8	10	8	0	41
1970	0	0	1	7	8	10	8	0	34
1971	0	0	9	8	9	9	8	0	43
1972	0	0	0	3	0	8	9	0	20
1973	0	0	7	1	7	8	10	0	33
1974	0	0	2	6	8	9	9	0	34
TOTAL	0	0	66	87	110	123	122	0	508

TABLE 79 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL, MINIMUM RELEASE 15000 CFS MARCH THROUGH MAY; 5000 CFS REMAINDER OF YEAR EXCEPT WHEN INFLOW LESS THAN 5000 CFS RELEASE NET INFLOW, BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	MAR	PR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	0	0	0	22	30	31	83
1962	0	0	8	30	31	31	30	31	161
1963	0	0	0	0	25	31	30	31	117
1964	0	0	2	30	31	31	30	31	155
1965	0	0	7	30	31	31	30	31	160
1966	0	0	0	0	30	31	30	31	122
1967	0	0	0	0	24	31	30	31	116
1968	10	0	26	0	4	31	30	31	132
1969	23	7	0	5	30	31	30	31	157
1970	0	0	0	0	0	26	30	31	87
1971	0	0	0	14	31	31	30	31	137
1972	0	0	0	0	0	5	30	31	66
1973	0	0	0	0	2	31	30	31	94
1974	0	0	0	0	1	29	30	31	91
TOTAL	33	7	43	109	240	392	420	434	1678

TABLE 80 -- MINIMUM POOL ELEVATION MINIMUM RELEASE 15000 CFS MARCH THROUGH MAY; 5000 CFS REMAINDER OF YEAR EXCEPT WHEN INFLOW LESS THAN 5000 CFS RELEASE NET INFLOW, BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1961	107.23	107.23	106.67	105.36	99.25	93.45	84.31	82.88
1962	106.09	107.23	90.31	75.39	71.03	71.03	64.20	-8888.00
1963	101.60	105.69	101.44	100.94	89.72	84.48	82.11	82.11
1964	104.07	107.23	95.63	80.81	55.39	53.58	53.58	53.58
1965	104.91	103.05	90.50	73.43	72.23	66.88	66.21	-8888.00
1966	107.23	102.46	106.09	99.41	94.32	94.32	92.82	82.14
1967	103.88	106.99	106.37	102.40	90.41	82.07	66.09	-8888.00
1968	92.46	101.06	91.04	105.04	98.33	89.78	83.72	63.83
1969	78.63	77.38	103.33	97.57	88.84	81.46	64.75	54.47
1970	106.11	107.23	106.57	103.72	99.70	88.82	75.41	54.27
1971	107.23	105.73	103.48	94.73	81.84	68.17	-8888.00	-8888.00
1972	107.15	107.23	107.23	105.96	106.45	97.37	86.14	63.10
1973	105.20	105.99	105.43	106.12	98.21	90.54	82.62	56.89
1974	106.57	107.23	106.12	101.17	98.29	89.89	76.90	43.34

TABLE 81 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL, MINIMUM RELEASE 2500 CFS EXCEPT WHEN INFLOW IS LESS THAN 2500 CFS RELEASE NET INFLOW, BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	1	0	5	8	9	0	23
1962	0	0	2	9	9	8	10	0	38
1963	0	0	0	2	8	9	9	0	28
1964	0	0	2	8	8	10	8	0	36
1965	0	0	10	8	9	9	8	0	44
1966	0	0	4	6	10	8	8	0	36
1967	0	0	2	2	10	8	9	0	31
1968	0	0	2	5	8	9	9	0	33
1969	0	0	5	7	8	10	8	0	38
1970	0	0	1	2	7	9	8	0	27
1971	0	0	9	8	9	9	8	0	43
1972	0	0	0	3	0	5	9	0	17
1973	0	0	7	1	7	8	10	0	33
1974	0	0	2	3	5	9	9	0	28
TOTAL	0	0	47	64	103	119	122	0	455

TABLE 82 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL, MINIMUM RELEASE 2500 CFS EXCEPT WHEN INFLOW IS LESS THAN 2500 CFS RELEAST NET INFLOW, BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	0	0	0	0	0	26	26
1962	0	0	0	0	25	31	30	31	117
1963	0	0	0	0	0	17	30	31	78
1964	0	0	0	0	25	31	30	31	117
1965	0	0	0	9	31	31	30	31	132
1966	0	0	0	0	9	31	30	31	101
1967	0	0	0	0	2	22	30	31	85
1968	0	0	0	0	0	10	30	31	71
1969	0	0	0	0	1	3	29	31	64
1970	0	0	0	0	0	0	16	31	47
1971	0	0	0	0	26	31	30	31	118
1972	0	0	0	0	0	0	11	31	42
1973	0	0	0	0	0	4	22	31	57
1974	0	0	0	0	0	0	22	31	53
TOTAL	0	0	0	9	119	211	340	429	1108

TABLE 83 -- MINIMUM ELEVATION MINIMUM RELEASE 2500 CFS EXCEPT WHEN INFLOW IS LESS THAN 2500 CFS RELEASE NET INFLOW, BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1961	107.23	107.23	106.67	105.50	103.50	102.72	100.25	93.83
1962	106.09	107.23	104.74	100.52	93.54	89.41	82.18	75.70
1963	107.23	106.44	105.83	105.36	100.77	95.61	89.93	88.16
1964	106.45	107.23	105.49	99.86	94.12	87.89	86.18	85.07
1965	104.91	103.05	102.14	97.15	91.48	82.91	72.80	59.13
1966	107.23	105.90	106.09	102.89	96.15	91.65	90.40	80.60
1967	106.63	106.99	106.37	104.68	99.36	94.97	92.02	87.34
1968	104.08	105.50	105.17	105.04	102.20	97.57	93.43	86.40
1969	104.14	106.36	104.55	103.06	98.99	98.02	93.13	88.54
1970	106.11	107.23	106.57	104.86	103.40	100.09	96.60	91.30
1971	107.23	105.73	103.48	100.81	95.25	92.54	85.23	74.80
1972	107.15	107.23	107.23	105.96	106.45	102.57	97.83	92.42
1973	106.87	105.99	105.43	106.12	102.06	98.63	96.33	91.79
1974	106.57	107.23	106.13	103.83	103.75	100.24	94.80	90.11

TABLE 84 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL
TARGET MINIMUM POOL ELEVATION 102.0
BALTIMORE WITHDRAWAL 100 CFS

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	1	0	0	1	0	0	2
1962	0	0	0	5	9	8	10	0	32
1963	0	0	0	0	2	3	7	0	12
1964	0	0	0	6	8	10	8	0	32
1965	0	0	10	8	9	9	8	0	44
1966	0	0	4	2	10	8	8	0	32
1967	0	0	2	0	7	8	9	0	26
1968	0	0	2	5	8	9	7	0	31
1969	0	0	5	4	8	7	8	0	32
1970	0	0	1	2	3	5	2	0	13
1971	0	0	9	8	9	9	8	0	43
1972	0	0	0	3	0	0	7	0	10
1973	0	0	7	1	5	6	7	0	26
1974	0	0	2	2	0	8	9	0	21
TOTAL	0	0	43	46	78	91	98	0	356

TABLE 85 -- NUMBER OF DEFICITS BELOW ELEVATION 102.0 FT. MSL
TARGET MINIMUM POOL ELEVATION 102.0
BALTIMORE WITHDRAWAL 100 CFS

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	1	1
1963	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	2	2	4	8
1966	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	1	1	1	3
1968	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	2	2	4
1972	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	3	5	8	16

TABLE 86 -- MINIMUM POOL ELEVATION
TARGET MINIMUM ELEVATION 102.0
BALTIMORE WITHDRAWAL 100 CFS

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1961	107.23	107.23	106.67	105.53	105.60	105.68	105.48	106.88
1962	106.10	107.23	105.15	105.73	105.26	105.23	104.56	101.94
1963	107.23	106.44	105.86	105.37	106.72	106.41	105.81	105.53
1964	106.41	107.23	105.42	104.22	104.33	104.08	103.30	103.86
1965	104.94	103.05	102.18	102.28	102.45	101.77	101.62	101.87
1966	107.23	105.93	106.11	105.14	105.38	104.79	104.73	104.00
1967	106.55	106.99	106.36	105.58	102.42	101.99	101.93	101.51
1968	105.14	105.53	105.20	105.07	103.42	104.89	104.71	103.01
1969	105.17	106.34	104.54	104.23	103.25	103.64	104.91	104.75
1970	106.13	107.23	106.60	105.35	104.83	105.44	105.63	104.00
1971	107.23	105.74	103.49	102.31	102.58	103.10	101.37	101.59
1972	107.13	107.23	107.23	105.99	106.48	105.25	105.66	105.53
1973	106.89	105.97	105.41	106.15	104.10	102.71	104.31	104.42
1974	106.56	107.23	106.16	104.96	105.59	104.46	102.40	102.27

TABLE 87 - MAXIMUM AVERAGE AND MINIMUM DAILY FLOW RELEASES (CFS)
TARGET ELEVATION 102.0
BALTIMORE WITHDRAWAL 100 CFS

YEAR	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	ANN.
H	252678	234768	90548	45240	24058	29782	19978	7960	252678
1961 A	97225	109963	54454	25399	13195	12966	7651	3972	40517
L	55662	34082	14338	3470	452	470	446	396	396
H	147798	251768	49453	17275	8495	17776	7655	42817	251768
1962 A	84413	111857	25264	8709	3742	4553	3306	19101	32512
L	12454	25322	457	470	376	368	381	454	368
H	231478	143998	57549	34266	16798	9872	9472	5706	231478
1963 A	104623	52173	32790	18213	7479	4503	3833	2600	28320
L	2797	10590	7190	450	483	424	355	355	355
H	459478	144478	183748	25910	12608	9373	4999	5237	459478
1964 A	134814	72262	47926	10996	5997	4052	2238	2578	35189
L	5797	40296	464	463	470	375	353	350	350
H	68620	73832	49944	25818	7979	11552	12576	23970	73832
1965 A	43193	58668	28270	10017	3666	4289	4575	10473	21128
L	19582	39260	452	454	356	-1450	-2123	458	-2123
H	167768	81237	98018	38996	9120	7703	12441	16656	167768
1966 A	78991	35014	57481	16680	4142	3539	4844	5618	25874
L	49368	6546	15763	451	372	352	376	418	352
H	186398	155798	110428	35169	30394	42729	24322	76753	186398
1967 A	83742	64306	67300	18879	14525	21111	10058	27324	38495
L	3272	32140	19785	839	460	465	475	454	454
H	197998	67590	143348	142748	68134	12016	44385	19216	197998
1968 A	57246	34885	49344	54299	18399	5689	13397	7334	30024
L	456	6411	4232	11975	456	463	474	477	456
H	96778	137768	63176	49859	46694	41229	14096	11392	137768
1969 A	28956	61179	34427	19872	15347	17873	6509	5172	23599
L	456	25718	7276	461	473	455	438	448	438
H	149467	334797	71847	39465	51067	26698	16957	52961	334797
1970 A	52474	139446	42531	20702	20461	10049	8655	18148	38847
L	21524	77697	12930	488	450	467	462	482	450
H	233768	105398	80517	30486	13427	40878	24016	25910	233768
1971 A	105782	64193	44840	14978	7011	12709	10784	9528	33774
L	41704	27738	8234	461	470	450	453	468	450
H	327798	240768	149348	1039747	164748	26790	13808	14288	1039747
1972 A	114437	92136	73768	190297	61090	13588	7210	7198	69639
L	51784	47028	22141	14468	7543	468	480	480	468
H	167768	174398	86128	70548	49517	33214	39851	47806	174398
1973 A	65491	80473	60380	36106	20752	14313	14864	14114	38244
L	10983	24631	34146	9802	456	452	479	450	450
H	138768	207398	97828	34182	70216	26874	43906	26438	207398
1974 A	61878	93194	39782	18054	21958	10052	20516	11720	34531
L	33119	21269	13170	463	465	473	462	456	456

TABLE 88 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL
TARGET ELEVATION 99.2, BALTIMORE WITHDRAWAL 100 CFS

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	1	0	0	1	0	0	2
1962	0	0	0	5	9	8	10	0	32
1963	0	0	0	0	2	3	7	0	12
1964	0	0	0	6	8	10	8	0	32
1965	0	0	10	8	9	9	8	0	44
1966	0	0	4	2	10	8	8	0	32
1967	0	0	2	0	7	8	9	0	26
1968	0	0	2	5	8	9	7	0	31
1969	0	0	5	4	8	7	8	0	32
1970	0	0	1	2	3	5	2	0	13
1971	0	0	9	8	9	9	8	0	43
1972	0	0	0	3	0	0	7	0	10
1973	0	0	7	1	5	6	7	0	26
1974	0	0	2	2	0	8	9	0	21
TOTAL	0	0	43	46	78	91	98	0	356

TABLE 89 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL
TARGET ELEVATION 99.2, BALTIMORE WITHDRAWAL 100 CFS

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	2	2
1966	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	2	2

TABLE 90 -- MINIMUM ELEVATION
TARGET ELEVATION 99.2
BALTIMORE WITHDRAWAL 100 CFS

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1961	107.23	107.23	106.67	105.53	105.60	105.68	105.48	106.88
1962	106.10	107.23	105.15	105.73	105.26	105.23	104.56	101.94
1963	107.23	106.44	105.86	105.37	106.72	106.41	105.81	105.53
1964	106.41	107.23	105.42	104.22	104.33	104.08	103.30	103.86
1965	104.94	103.05	102.18	102.28	102.45	101.37	100.51	98.98
1966	107.23	105.93	106.11	105.14	105.38	104.79	104.73	104.00
1967	106.55	106.99	106.36	105.58	102.42	101.99	101.67	100.70
1968	105.14	105.53	105.20	105.07	103.42	104.89	104.71	103.01
1969	105.17	106.34	104.54	104.23	103.25	103.64	104.91	104.75
1970	106.13	107.23	106.60	105.35	104.83	105.44	105.63	104.00
1971	107.23	105.74	103.49	102.31	102.58	103.10	100.99	99.97
1972	107.13	107.23	107.23	105.99	106.48	105.25	105.66	105.53
1973	106.89	105.97	105.41	106.15	104.10	102.71	104.31	104.42
1974	106.56	107.23	106.16	104.96	105.59	104.46	102.40	102.27

TABLE 91 - MAXIMUM AVERAGE AND MINIMUM DAILY FLOW RELEASES (cfs)
TARGET ELEVATION 99.2, BALTIMORE WITHDRAWAL 100 cfs

YEAR		MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEP.	OCT.	ANN.
	H	252,678	234,768	90,548	45,240	24,058	29,782	19,978	7,960	252,678
1961	A	97,226	109,963	54,454	25,399	13,195	12,966	7,651	3,972	40,517
	L	55,662	34,082	14,338	3,470	452	470	446	396	396
	H	147,798	251,768	49,453	17,275	8,495	17,776	7,655	42,817	251,768
1962	A	84,413	111,857	25,264	8,709	3,742	4,553	3,306	19,141	32,517
	L	12,454	25,322	457	470	376	368	381	454	368
	H	231,478	143,998	57,549	34,266	16,798	9,872	9,472	5,706	231,478
1963	A	104,623	52,173	32,790	18,213	7,479	4,503	3,833	2,600	28,320
	L	2,797	10,590	7,190	450	483	424	355	355	355
	H	459,478	144,478	183,748	25,910	12,608	9,373	4,999	5,237	459,478
1964	A	134,814	72,262	47,926	10,996	5,997	4,052	2,238	2,578	35,189
	L	5,797	40,296	464	463	470	375	353	350	350
	H	68,620	73,832	49,944	25,818	7,979	11,552	12,576	23,970	73,832
1965	A	43,193	58,668	28,270	10,017	3,666	4,388	4,706	10,783	21,176
	L	19,582	39,260	452	454	356	362	391	458	356
	H	167,768	81,237	98,018	38,996	9,120	7,703	12,441	16,656	167,768
1966	A	78,991	35,014	57,481	16,680	4,142	3,539	4,844	5,618	25,874
	L	49,368	6,546	15,763	451	372	352	376	418	352
	H	186,398	155,798	110,428	35,169	30,394	42,729	25,435	76,753	186,398
1967	A	83,742	64,306	67,300	18,879	14,525	21,145	10,101	27,420	38,517
	L	3,272	32,140	19,785	839	460	465	475	454	454
	H	197,998	67,590	143,348	142,748	68,134	12,016	44,385	19,216	197,998
1968	A	57,246	34,885	49,344	54,299	18,399	5,689	13,397	7,334	30,024
	L	456	6,411	4,232	11,975	456	463	474	477	456
	H	96,778	137,768	63,176	49,859	46,694	41,229	14,096	11,392	137,768
1969	A	28,956	61,179	34,427	19,872	15,347	17,873	6,509	5,172	23,599
	L	456	25,718	7,276	461	473	455	438	448	438
	H	149,467	334,797	71,847	39,465	51,067	26,698	16,957	52,961	334,797
1970	A	52,474	139,446	42,531	20,702	20,461	10,049	8,655	18,148	38,847
	L	21,524	77,697	12,930	488	450	467	462	482	450
	H	233,768	105,398	80,517	30,486	13,427	40,878	24,016	27,759	233,768
1971	A	105,782	64,193	44,840	14,978	7,011	12,709	10,954	9,662	33,812
	L	41,704	27,738	8,234	461	470	450	453	468	450
	H	327,798	240,768	149,348	1,039,747	164,748	26,790	13,808	14,288	1,039,747
1972	A	114,437	92,136	73,768	190,297	61,090	13,588	7,210	7,198	69,639
	L	51,784	47,028	22,141	14,468	7,543	468	480	480	468
	H	167,768	174,398	86,128	70,548	49,517	33,214	39,851	47,806	174,398
1973	A	65,491	80,473	60,380	36,106	20,752	14,313	14,864	14,114	38,244
	L	10,983	24,631	34,146	9,802	456	452	479	450	450
	H	138,768	207,398	97,828	34,182	70,216	26,874	43,906	26,438	207,398
1974	A	61,878	93,194	39,782	18,054	21,958	10,052	20,516	11,720	34,531
	L	33,119	21,269	13,170	463	465	473	462	456	456

The number of deficits below elevation 107.2 are shown in Table 92. There are no days where the pool elevation is below 99.2 for this case. Note there are 570 days where the pool elevation is less than the target elevation. The minimum pool elevations are shown in Table 93. The lowest minimum pool elevation is 106.04 ft. msl in October 1967.

The average and range of daily flow releases are shown in Table 94 for each month of each year. Negative releases occur in five years and minimum releases of the order of 400 cfs occur often.

4) Target Elevation 99.2; Baltimore Withdrawal 500 mgd (774 cfs).

The number of deficits below elevations 107.2 and 99.2 are shown in Tables 95 and 96, respectively. The minimum pool elevations are shown in Table 97. Note that there are only four days on which the pool elevation is below 99.2 and the lowest minimum pool elevation is 98.76 ft. msl. This is very similar to the base case shown in Tables 33 and 34.

The average and range of daily flow releases is shown in Table 98 for each month of each year.

The following cases are in addition to those specifically requested by Maryland. These cases were simulated because it was convenient to include them in a computer run. Statistics of releases were not computed for these cases because of time and cost constraints. Those computations could be made if deemed necessary.

5) Target Elevation 107.2; Baltimore Withdrawal 250 mgd (388 cfs).

The number of deficits below elevation 107.2 are shown in Table 99. The minimum pool elevations are shown in Table 100. There are no deficits below elevation 99.2 ft. msl. The lowest minimum pool elevation is 106.06 in October 1967.

6) Target Elevation 102.0; Baltimore Withdrawal 250 mgd (388 cfs).

The number of deficits below elevations 107.2 and 102.0 are shown in Tables 101 and 102, respectively. The minimum pool elevations are shown in Table 103. There are no deficits below elevation 99.2 for this case. Note there are 16 days on which the pool elevation is below the target elevation. The lowest minimum pool elevation is 101.36 ft. msl in September 1971.

TABLE 92 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL
TARGET ELEVATION 107.2
BALTIMORE WITHDRAWAL 100 CFS

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	3	11	9	8	3	2	36
1962	6	0	10	1	5	1	2	9	34
1963	0	5	7	10	2	2	4	4	34
1964	3	0	6	3	3	1	4	1	21
1965	9	4	8	6	2	6	4	7	46
1966	0	6	4	11	2	2	1	6	32
1967	3	1	4	14	12	10	4	8	56
1968	6	5	6	8	8	0	4	4	41
1969	6	3	9	11	6	10	4	1	50
1970	4	0	5	12	15	4	0	8	48
1971	0	3	4	12	3	5	8	4	39
1972	1	0	0	8	2	11	4	2	28
1973	1	5	2	6	11	13	8	6	52
1974	1	0	6	12	6	5	12	11	53
TOTAL	40	32	74	125	86	78	62	73	570

TABLE 93 -- MINIMUM POOL ELEVATION
TARGET ELEVATION 107.2
BALTIMORE WITHDRAWAL 100 CFS

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1961	107.23	107.23	106.95	106.41	106.37	106.42	106.79	107.04
1962	106.67	107.23	106.37	107.05	106.95	107.17	106.59	106.48
1963	107.23	106.71	106.43	106.37	107.13	106.99	106.84	106.99
1964	106.67	107.23	106.43	106.36	106.93	106.95	106.65	107.16
1965	106.40	106.18	106.36	106.41	107.12	106.66	106.70	106.57
1966	107.23	106.46	106.38	106.36	107.03	106.88	106.87	106.91
1967	106.77	106.99	106.94	106.40	106.37	106.41	106.53	106.04
1968	106.40	106.47	106.45	106.46	106.37	107.81	106.36	106.52
1959	106.37	106.34	106.48	106.41	106.53	106.36	106.99	107.05
1970	106.67	107.23	106.88	106.41	106.43	106.39	107.25	106.40
1971	107.23	106.46	105.63	106.40	106.72	106.65	106.41	106.20
1972	107.13	107.23	107.23	106.80	106.80	106.38	106.89	107.12
1973	106.89	106.52	106.74	106.48	106.39	106.39	106.39	106.37
1974	106.56	107.23	106.50	106.41	106.50	106.40	106.40	106.37

TABLE 94 - MAXIMUM AVERAGE AND MINIMUM DAILY FLOW RELEASES (CFS)
TARGET ELEVATION 107.2
BALTIMORE WITHDRAWAL 100 CFS

YEAR		MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	ANN.
	H	252678	234768	90548	45240	24058	28986	19978	7960	252678
1961	A	97226	109963	54431	25290	13310	12807	7818	3939	40511
	L	55662	34082	15783	5284	463	470	446	-257	-257
	H	147798	251768	49453	17275	8495	17776	7297	42817	.251768
1962	A	84413	111857	25092	8694	3674	4554	3211	19066	32464
	L	14506	25322	984	470	-566	267	-2026	483	-2026
	H	231478	143998	57549	34266	16798	9872	9472	5706	231478
1963	A	104623	52173	32790	18159	7468	4462	3752	2569	28293
	L	2797	13685	12143	475	483	-411	-1064	-475	-1064
	H	459478	144478	183748	24498	12608	9373	4999	5237	459478
1964	A	134755	72323	47769	10831	5937	4020	2132	2651	35133
	L	5797	40296	464	463	-610	-573	-1828	187	-1828
	H	68498	73832	49944	25818	7979	11552	12576	23970	73832
1965	A	42896	58413	28362	9861	3647	4247	4590	10566	21044
	L	19806	39260	1984	467	64	-1709	-1645	465	-1709
	H	167768	80670	98018	38996	9120	7703	12441	16656	167768
1966	A	78991	34995	57388	16591	4101	3492	4815	5511	25821
	L	49368	10808	16743	476	-296	-932	-980	-707	-980
	H	186398	155798	110428	34409	30394	42729	24322	73779	186398
1967	A	83742	64277	67328	18659	14411	20787	10001	27347	38409
	L	4334	32140	19785	2784	464	466	475	479	464
	H	197998	67590	143348	142748	67948	12016	44385	16953	197998
1968	A	57246	34809	49418	54011	18295	5689	13455	7111	29954
	L	1334	8139	7433	13651	470	463	475	477	463
	H	96778	137768	63147	49859	46694	41229	14096	11392	137768
1969	A	28924	61096	34190	20091	15166	17935	6462	5152	23558
	L	473	25718	7276	461	473	487	-410	-172	-410
	H	149467	334797	71847	39465	50117	26698	16957	52961	334797
1970	A	52474	139445	42499	20735	20199	10097	8759	17841	38794
	L	21584	77697	15378	3484	2484	467	465	482	465
	H	233768	105398	79054	29920	13408	40878	22909	24827	233768
1971	A	105782	63996	44683	14807	6919	12830	10739	9629	33720
	L	41704	27738	12535	461	470	481	472	468	461
	H	327798	240768	149348	1039747	164748	24308	13808	14288	1039747
1972	A	114437	92136	73768	190297	61090	13467	7127	7180	69611
	L	51784	47028	22141	15797	10459	469	480	480	469
	H	167768	174398	90818	70548	49517	32152	39851	47806	174398
1973	A	65491	80307	60541	35977	20548	14430	14974	13941	38209
	L	10983	24631	34146	14064	466	474	479	464	· 464
	H	138768	207398	97828	32732	70216	26874	43347	23500	207398
1974	A	61794	93280	39646	18099	21853	9896	24076	11466	34449
	L	33119	21269	15347	464	465	473	462	471	462

TABLE 95 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL
TARGET ELEVATION 99.2, BALTIMORE WITHDRAWAL 500
MGD (774 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	1	0	0	1	1	0	3
1962	0	0	1	7	9	8	10	0	35
1963	0	0	0	0	3	4	9	0	16
1964	0	0	0	6	8	10	8	0	32
1965	0	0	10	8	9	9	8	0	44
1966	0	0	4	3	10	8	8	0	33
1967	0	0	2	0	7	8	9	0	26
1968	0	0	2	5	8	9	8	0	32
1969	0	0	5	5	8	8	8	0	34
1970	0	0	1	2	3	5	2	0	13
1971	0	0	9	8	9	9	8	0	43
1972	0	0	0	3	0	0	8	0	11
1973	0	0	7	1	6	6	7	0	27
1974	0	0	2	2	0	8	9	0	21
TOTAL	0	0	44	50	80	93	103	0	370

TABLE 96 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL
TARGET ELEVATION 99.2, BALTIMORE WITHDRAWAL 500
MGD (774 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	4	4
1966	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	4	4

TABLE 97 -- MINIMUM ELEVATION
TARGET ELEVATION 99.2
BALTIMORE WITHDRAWAL 500 MGD (774 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1961	107.23	106.20	106.67	105.46	105.81	105.83	105.41	106.52
1962	106.08	107.23	105.10	105.68	104.87	104.80	104.17	101.83
1963	107.23	106.44	105.79	105.35	106.47	106.06	105.46	105.12
1964	106.51	107.23	105.58	104.07	103.89	103.58	102.78	103.29
1965	104.88	103.05	102.13	102.07	101.91	100.81	100.06	98.76
1966	107.23	105.85	106.07	104.75	104.71	104.12	104.05	103.47
1967	106.75	107.01	106.38	105.52	102.46	101.70	101.37	100.57
1968	105.23	105.46	105.13	105.00	103.33	104.55	104.54	102.31
1969	105.39	106.37	104.58	104.12	103.15	103.67	105.03	104.89
1970	106.07	107.23	106.53	105.29	104.90	105.55	105.72	104.07
1971	107.23	105.72	103.46	102.17	102.62	103.11	101.02	100.02
1972	107.18	107.23	107.23	105.92	106.41	105.10	105.68	105.46
1973	106.84	106.00	105.45	106.08	104.05	102.60	104.51	104.46
1974	106.59	107.23	106.09	104.88	105.80	104.56	102.25	102.13

TABLE 98 - MAXIMUM AVERAGE AND MINIMUM DAILY FLOW RELEASES (CFS)
TARGET ELEVATION 99.2
BALTIMORE WITHDRAWAL 500 MGD (774 CFS)

YEAR		MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	ANN.
	H	252004	234094	89778	44664	23465	29189	18906	6672	252004
1961	A	96551	109289	53778	24736	12501	12311	6997	3305	39847
	L	54915	33209	13477	2884	456	473	406	356	356
	H	147124	251094	48797	16203	7207	16698	6589	42222	251094
1962	A	83739	111185	24601	8050	3075	3854	2674	18444	31846
	L	11867	24720	461	473	353	351	350	457	350
	H	230804	143324	56954	33673	15726	8773	8296	4419	230804
1963	A	103949	51503	32121	17578	6774	3839	3170	1892	27646
	L	2123	10305	6604	453	485	384	353	360	353
	H	458804	143804	183074	25317	11530	8301	3943	4244	458804
1964	A	134135	71593	47274	10347	5302	3401	1546	1927	34521
	L	5123	39423	467	467	430	350	380	357	350
	H	68025	73176	49368	25225	6692	10474	11498	15578	73176
1965	A	42527	57997	27624	9346	3004	3724	4006	8129	20784
	L	18709	38388	456	458	359	360	351	490	351
	H	167094	80490	97344	38419	7951	6637	11370	15578	167094
1966	A	78322	34342	56801	16066	3498	2827	4147	4972	25207
	L	48744	5959	14890	455	352	362	392	378	352
	H	185724	155124	109754	34545	29801	42134	24801	76006	185724
1967	A	83068	63623	66642	18175	13883	20499	9412	26741	37845
	L	2214	31267	19184	451	452	469	478	457	451
	H	197324	66967	142674	142074	67540	10938	43808	18138	197324
1968	A	56563	34225	48666	53636	17739	5023	12744	6634	29353
	L	459	5826	3646	11389	459	423	452	436	423
	H	96104	137094	62520	49282	46118	40634	13018	10314	137094
1969	A	28278	60509	33734	19224	14678	17174	5819	4467	22918
	L	459	25117	6218	465	477	450	397	407	397
	H	148793	334123	71173	38870	50321	26105	15885	52367	334123
1970	A	51800	138772	41857	20033	19738	9436	7963	17453	38171
	L	20651	77023	12345	456	453	471	466	486	453
	H	233094	104724	79771	29893	12355	40301	22938	27125	233094
1971	A	105111	63519	44159	14285	6345	12055	10242	9003	33136
	L	41084	26865	7648	465	473	453	456	471	453
	H	327124	240094	148674	1039073	164074	26197	12730	13210	1039073
1972	A	113764	91452	73109	189616	60419	12902	6552	6528	68967
	L	51207	46156	21539	13595	6958	451	483	483	451
	H	167094	173724	85454	69874	48940	32621	39275	47230	173724
1973	A	64815	79798	59710	35439	20111	13563	14203	13504	37575
	L	10228	23758	33274	9216	459	450	451	454	450
	H	138094	206724	97154	33589	69640	26281	43250	25845	206724
1974	A	61201	92527	39114	17370	21269	9371	19878	11051	33859
	L	32500	20668	12571	467	468	477	466	459	459

TABLE 99 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL
TARGET ELEVATION 107.2, BALTIMORE WITHDRAWAL 250
MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	3	11	8	8	1	0	31
1962	6	0	9	1	5	1	4	9	35
1963	0	5	7	11	3	3	4	4	37
1964	3	0	6	3	3	1	4	2	22
1965	9	4	8	5	2	6	3	7	44
1966	0	6	4	11	3	3	1	5	33
1967	3	1	4	14	12	10	4	6	54
1968	6	5	6	8	8	0	4	4	41
1969	6	3	9	11	6	10	4	1	50
1970	5	0	5	12	15	5	0	8	50
1971	0	3	4	12	4	6	8	4	41
1972	1	0	0	7	2	9	3	1	23
1973	1	5	3	7	10	10	8	6	50
1974	1	0	7	12	6	5	12	9	52
TOTAL	41	32	75	125	87	77	60	66	563

TABLE 100 -- MINIMUM ELEVATION
TARGET ELEVATION 107.2
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1961	107.23	107.23	106.93	106.41	106.37	105.42	105.78	107.48
1962	106.67	107.23	106.37	107.07	106.91	107.14	105.44	106.47
1963	107.23	106.74	106.43	106.37	107.09	105.99	105.84	106.85
1964	106.71	107.23	106.45	106.36	105.89	106.91	105.50	107.01
1965	106.42	106.20	106.36	106.43	107.12	106.67	106.70	105.59
1966	107.23	106.46	106.39	106.36	106.94	105.88	106.72	106.86
1967	106.79	106.99	106.95	106.40	106.36	105.40	106.55	105.06
1968	106.42	106.47	106.44	106.45	105.37	107.71	106.36	106.54
1969	106.40	106.36	106.47	106.41	106.53	106.37	105.95	107.06
1970	106.67	107.23	106.85	106.40	105.42	106.41	107.25	105.40
1971	107.23	106.48	105.65	106.40	105.63	106.67	106.40	106.25
1972	107.15	107.23	107.23	106.77	106.78	106.37	105.96	107.04
1973	106.87	106.54	106.76	106.46	106.38	106.41	106.38	106.37
1974	106.57	107.23	106.48	106.41	106.52	106.39	105.40	106.37

TABLE 101 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL TARGET ELEVATION 102.0, BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	1	0	0	1	0	0	2
1962	0	0	1	7	9	8	10	0	35
1963	0	0	0	0	2	4	9	0	15
1964	0	0	0	6	8	10	8	0	32
1965	0	0	10	8	9	9	8	0	44
1966	0	0	4	2	10	8	8	0	32
1967	0	0	2	0	7	8	9	0	26
1968	0	0	2	5	8	9	7	0	31
1969	0	0	5	4	8	7	8	0	32
1970	0	0	1	2	3	5	2	0	13
1971	0	0	9	8	9	9	8	0	43
1972	0	0	0	3	0	0	7	0	10
1973	0	0	7	1	5	6	7	0	26
1974	0	0	2	2	0	8	9	0	21
TOTAL	0	0	44	48	78	92	100	0	362

TABLE 102 -- NUMBER OF DEFICITS BELOW ELEVATION 102.0 FT. MSL TARGET ELEVATION 102.0, BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	1	1
1963	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	2	2	4	8
1966	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	1	1	1	3
1968	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	2	2	4
1972	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	3	5	8	16

TABLE 103 -- MINIMUM POOL ELEVATION TARGET ELEVATION 102.0 BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1961	107.23	107.23	106.67	105.50	105.69	105.85	105.45	106.72
1962	106.09	107.23	105.12	105.70	105.09	105.03	104.38	101.85
1963	107.23	106.44	105.83	105.36	106.61	106.26	105.65	105.31
1964	106.45	107.23	105.49	104.15	104.15	103.86	103.08	103.60
1965	104.91	103.05	102.14	102.18	102.20	101.51	101.62	101.85
1966	107.23	105.90	106.09	104.96	105.09	104.48	104.39	103.73
1967	106.63	106.99	106.37	105.56	102.43	101.91	101.93	101.59
1968	105.18	105.50	105.17	105.04	103.38	104.76	104.63	102.91
1969	105.26	106.36	104.55	104.17	103.20	103.63	104.94	104.79
1970	106.11	107.23	106.57	105.32	104.91	105.47	105.65	104.00
1971	107.23	105.73	103.48	102.23	102.57	103.13	101.36	101.60
1972	107.15	107.23	107.23	105.96	106.45	105.27	105.78	105.62
1973	106.87	105.99	105.43	106.12	104.07	102.64	104.37	104.48
1974	106.57	107.23	106.13	104.92	105.73	104.50	102.32	102.20

7) Target Elevation 99.2; Baltimore Withdrawal 250 mgd (388 cfs).

The number of deficits below elevations 107.2 and 99.2 are shown in Tables 104 and 105, respectively. The minimum pool elevations are shown in Table 106. Note there are only two days on which the pool elevation is below 99.2 and the lowest minimum pool elevation is 98.87 ft. msl in October 1965.

8) Target Elevation 107.2; Baltimore Withdrawal 500 mgd (774 cfs).

The number of deficits below elevation 107.2 are shown in Table 107. The minimum pool elevations are shown in Table 108. There are no deficits below elevation 99.2 for this case. Note there are 571 days in which the pool elevation is below the target elevation, and the minimum pool elevation is 106.09 in October 1967.

9) Target Elevation 102.0; Baltimore Withdrawal 500 mgd (774 cfs).

The number of deficits below elevations 107.2 and 102.0 are shown in Tables 109 and 110, respectively. There are no deficits below elevation 99.2 ft. msl for this case. The minimum pool elevations are given in Table 111. Note there are 17 days on which the pool elevation is below the target elevation, and the lowest minimum pool elevation is 101.50 in August 1965.

E. Discussion of Tradeoffs

1. Comparison of Fixed Release Schemes

Table 112 presents a summary of the number of deficits below elevations 107.2 and 99.2, the minimum pool elevations, and the peaking power generation lost for the various combinations of minimum release requirement and Baltimore withdrawal.

In Table 112, the amount of peaking power generation lost prior to the date on which the pool is drawn down below elevation 99.2 ft. msl, is shown in column 6. That amount of generation is expressed as a percentage of the amount of peaking power generation that would have occurred in that same period in the absence of a release requirement and/or Baltimore withdrawal, in column 7. In column 8 the amount of peaking power generation that could have occurred during the period following drawdown of the pool below elevation 99.2 ft. msl in the absence of a release requirement and/or Baltimore withdrawal is shown. The total peaking generation that could have taken place during the entire period simulated is shown in column 9.

TABLE 104 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL
TARGET ELEVATION 99.2, BALTIMORE WITHDRAWAL 250
MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	1	0	0	1	0	0	2
1962	0	0	1	7	9	8	10	0	35
1963	0	0	0	0	2	4	9	0	15
1964	0	0	0	6	8	10	8	0	32
1965	0	0	10	8	9	9	8	0	44
1966	0	0	4	2	10	8	8	0	32
1967	0	0	2	0	7	8	9	0	26
1968	0	0	2	5	8	9	7	0	31
1969	0	0	5	4	8	7	8	0	32
1970	0	0	1	2	3	5	2	0	13
1971	0	0	9	8	9	9	8	0	43
1972	0	0	0	3	0	0	7	0	10
1973	0	0	7	1	5	6	7	0	26
1974	0	0	2	2	0	8	9	0	21
TOTAL	0	0	44	48	78	92	100	0	362

TABLE 105 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL
TARGET ELEVATION 99.2, BALTIMORE WITHDRAWAL 250
MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	2	2
1966	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	2	2

TABLE 106 -- MINIMUM ELEVATIONS
TARGET ELEVATION 99.2
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1961	107.23	107.23	106.67	105.50	105.69	105.85	105.45	106.72
1962	106.09	107.23	105.12	105.70	105.09	105.03	104.38	101.85
1963	107.23	106.44	105.83	105.36	106.61	106.26	105.65	105.31
1964	106.45	107.23	105.49	104.15	104.15	103.86	103.08	103.60
1965	104.91	103.05	102.14	102.18	102.20	101.11	100.31	98.87
1966	107.23	105.90	106.09	104.96	105.08	104.48	104.39	103.73
1967	106.63	106.99	106.37	105.56	102.43	101.91	101.59	100.69
1968	105.18	105.50	105.17	105.04	103.38	104.76	104.63	102.91
1969	105.26	106.36	104.55	104.17	103.20	103.63	104.94	104.79
1970	106.11	107.23	106.57	105.32	104.91	105.47	105.65	104.00
1971	107.23	105.73	103.48	102.23	102.57	103.13	100.98	99.97
1972	107.15	107.23	107.23	105.96	106.45	105.27	105.78	105.62
1973	106.87	105.99	105.43	106.12	104.07	102.64	104.37	104.48
1974	106.57	107.23	106.13	104.92	105.73	104.50	102.32	102.20

TABLE 107 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL
TARGET ELEVATION 107.2, BALTIMORE WITHDRAWAL 500
MGD (774 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	1	3	11	8	8	1	2	34
1962	6	0	9	1	4	1	3	9	33
1963	0	5	7	10	4	3	4	4	37
1964	3	0	6	3	2	2	4	3	23
1965	10	5	8	5	2	6	3	7	46
1966	0	6	4	11	3	3	1	6	34
1967	3	1	4	14	12	10	4	6	54
1968	6	5	6	8	8	0	3	7	43
1969	6	3	9	11	6	10	3	1	49
1970	5	0	5	12	15	3	0	7	47
1971	0	4	4	11	6	7	7	4	43
1972	1	0	0	7	2	9	5	1	25
1973	1	5	3	8	10	8	10	6	51
1974	1	0	7	12	6	5	12	9	52
TOTAL	42	35	75	124	88	75	60	72	571

TABLE 108 -- MINIMUM POOL ELEVATIONS
TARGET ELEVATION 107.2
BALTIMORE WITHDRAWAL 500 MGD (774 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1961	107.23	106.20	106.91	106.40	106.36	106.41	105.78	107.05
1962	106.66	107.23	106.36	107.10	106.89	107.12	105.25	105.47
1963	107.23	106.78	106.42	105.36	107.06	106.99	106.84	105.65
1964	106.77	107.23	106.48	106.38	106.83	106.89	105.31	105.81
1965	106.45	106.23	106.39	106.46	107.10	106.68	106.70	106.62
1966	107.23	106.45	106.41	105.38	106.94	106.89	105.52	105.92
1967	106.82	107.01	106.96	106.39	106.36	106.40	106.58	106.09
1968	106.42	106.46	106.44	105.45	106.36	107.54	105.39	105.57
1969	106.42	106.39	106.47	106.40	106.41	106.40	106.90	107.07
1970	106.68	107.23	106.82	105.40	105.42	105.44	107.33	105.39
1971	107.23	106.51	105.68	106.39	106.69	106.70	106.40	105.28
1972	107.18	107.23	107.23	106.73	106.74	105.37	107.02	105.98
1973	106.84	106.57	106.79	106.46	105.38	106.44	106.38	105.36
1974	106.59	107.23	106.47	106.40	106.55	106.39	105.39	106.36

TABLE 109 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL
TARGET ELEVATION 102.0, BALTIMORE WITHDRAWAL 500
MGD (774 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	1	0	0	1	1	0	3
1962	0	0	1	7	9	8	10	0	35
1963	0	0	0	0	3	4	9	0	16
1964	0	0	0	6	8	10	8	0	32
1965	0	0	10	8	9	9	8	0	44
1966	0	0	4	3	10	8	8	0	33
1967	0	0	2	0	7	8	9	0	26
1968	0	0	2	5	8	9	8	0	32
1969	0	0	5	5	8	8	8	0	34
1970	0	0	1	2	3	5	2	0	13
1971	0	0	9	8	9	9	8	0	43
1972	0	0	0	3	0	0	8	0	11
1973	0	0	7	1	6	6	7	0	27
1974	0	0	2	2	0	8	9	0	21
TOTAL	0	0	44	50	80	93	103	0	370

TABLE 110 -- NUMBER OF DEFICITS BELOW ELEVATION 102.0 FT. MSL
TARGET ELEVATION 102.0, BALTIMORE WITHDRAWAL 500
MGD (774 CFS)

YEAR	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1961	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	1	1
1963	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	1	2	2	3	8
1966	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	1	1	2	4
1968	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	2	2	4
1972	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	1	3	5	8	17

TABLE 111 -- MINIMUM POOL ELEVATIONS
TARGET ELEVATION 102.0
BALTIMORE WITHDRAWAL 500 MGD (774 CFS)

YEAR	MAR	APR	MAY	JUN	JUL.	AUG	SEP	OCT
1961	107.23	106.20	106.67	105.46	105.81	105.83	105.41	106.52
1962	106.08	107.23	105.10	105.68	104.87	104.80	104.17	101.83
1963	107.23	106.44	105.79	105.35	106.47	106.06	105.46	105.12
1964	106.51	107.23	105.58	104.07	103.89	103.58	102.78	103.29
1965	104.89	103.05	102.13	102.07	101.98	101.50	101.60	101.72
1966	107.23	105.85	106.07	104.75	104.71	104.12	104.05	103.47
1967	106.75	107.01	106.38	105.52	102.46	101.70	101.92	101.70
1968	105.23	105.46	105.13	105.00	103.33	104.55	104.54	102.81
1969	105.39	106.37	104.58	104.12	103.15	103.67	105.03	104.89
1970	106.07	107.23	106.53	105.29	104.90	105.55	105.72	104.07
1971	107.23	105.72	103.46	102.17	102.62	103.11	101.40	101.62
1972	107.18	107.23	107.23	105.92	106.41	105.10	105.68	105.46
1973	106.84	106.00	105.45	106.08	104.05	102.60	104.51	104.46
1974	106.59	107.23	106.09	104.88	105.80	104.56	102.25	102.13

TABLE 112 - SUMMARY OF NUMBER OF DEFICITS, MINIMUM POOL ELEVATIONS AND PEAKING POWER GENERATION LOST, BASED ON FIXED RELEASE REQUIREMENT

RELEASE REQUIREMENT	BALTIMORE WITHDRAWAL	NO. OF DEFICITS (DAYS) BELOW ELEV. 107.2 FT.MSL	NO. OF DEFICITS (DAYS) BELOW ELEV. 99.2 FT.MSL	MIN. POOL ELEV. FT.MSL	PEAKING POWER GENERATION LOST: PRE DRAWDOWN AMOUNT (MILL.CFS DAYS) (MILL. KWHRS.)	%	PEAKING POWER GENERATION LOST: POST DRAWDOWN AMOUNT (MILL. CFS DAYS) (MILL. KWHRS.)	TOTAL GENERATION AVAILABLE FOR PERIOD SIMULATED (MILL.CFS DAYS)
1. Zero	Zero	355	2	98.92	0	0		
2. 2500 cfs March Thru June, Zero Remainder of Year.	100 mgd	399	202	92.76	3.1 (490)	7.6	2.2 (348)	42.4
3. 5000 cfs March Thru June, Zero Remainder of Year.	100 mgd (155 cfs)	438	642	84.73	5.1 (806)	14.0	6.1 (964)	42.2
4. 5000 cfs March Thru June, Zero Remainder of Year.	250 mgd (388 cfs)	440	669	84.42	5.5 (869)	15.1	6.2 (980)	42.4
5. 2500 cfs Year Round.	100 mgd (155 cfs)	452	1087	60.40	4.2 (664)	13.2	10.6 (1675)	42.4
6. 5000 cfs Year Round.	100 mgd (155 cfs)	481	1528	< 30	6.0 (948)	21	13.8 (2180)	42.4
7. 5000 cfs Year Round Except when Inflow Less Than 5000 cfs Release Net Inflow.	250 mgd (388 cfs)	483	1538	< 30±	6.18 (976)	21.7	14 (2210)	42.4
8. 15000 cfs March Thru May, 5000 cfs Remainder of Year.	Zero	504	1646	< 30±	8.8 (1390)	37.9	19.2 (3034)	42.4
9. 5000 cfs Except When Inflow less than 5000 cfs, Release Net Infow.	100 mgd (155 cfs)	481	1528	< 30±				
10. 5000 cfs Year Round.	250 mgd (388 cfs)	483	1538	< 30±				
11. 5000 cfs March Thru June, Otherwise Release Net Inflow.	250 mgd (388 cfs)	483	1546	< 30±				
12. 15000 cfs March Thru May; 5000 cfs Remainder of Year, Except when Inflow Less than 5000 cfs Release Net Inflow.	Zero	504	1646	< 30±				
13. 2500 cfs Except When Inflow Less Than 2500 cfs Release Net Inflow.	Zero	450	1063	62.32				
14. 2500 cfs Except When Inflow Less Than 2500 cfs Release Net Inflow.	250 mgd (388 cfs)	455	1108	59.13				
15. Minimum Release 15000 cfs March Thru May, 5000 cfs Remainder of Year Except When Inflow Less Than 5000 cfs Release Net Inflow	250 mgd (388 cfs)	508	1678	< 30±				

Note: 1. 1 cfs day is approximately equal to 158 Kwhr.
2. Total average annual plant generation is 1700 x 10^6 Kwhrs.

All values are accumulated over the 14-year period which was simulated.

In Table 113, some additional information on power generation lost is shown. In column 3, the amount of generation which could have occurred during the period prior to drawdown of the pool below elevation 99.2 ft. msl is expressed as a percentage of the total generation during the 8-month period, in the absence of a release requirement and/or Baltimore withdrawal. For example, for the first case shown, the total power generation which could have occurred prior to drawdown below elevation 99.2 ft. msl is about 95% of that which could have occurred during the entire period simulated. In column 4 the amount of power generation lost prior to drawdown of the pool below elevation 99.2 ft. msl is shown. In column 5, the total amount of peaking power that could have been generated in the absence of a release requirement and/or Baltimore withdrawal is shown. In column 6, the value in column 4 is expressed as a percentage of the value in column 5. This corresponds with the value in column 7 of Table 112.

In column 7 of Table 113, the amount of generation lost during the period following the date on which the pool is first drawn down below elevation 99.2 ft. msl is shown. In column 5, the total power generation lost (sum of columns 4 and 7) is expressed as a percentage of total generation that could have occurred in the absence of a release requirement and/or Baltimore withdrawal.

The various schemes are ordered with respect to number of deficits below elevation 107.2 as shown in Table 114. A similar ranking for the number of deficits below elevation 99.2 is given in Table 115. Note that the ranking is essentially the same for both levels.

In evaluating these schemes and the number of deficits created several things should be kept in mind. Firstly, all schemes drawdown the pool to a greater or lesser extent due to the use of the operating curves in the program, and the absence of any modification to force a flow balance. Secondly, if the flow represented by the amount of peaking power generation lost were redistributed so that the flow balance was maintained the deficits would be minimized if not eliminated. The lack of flow balance implies that the required flows are to be provided from storage, in which case the drawdowns shown will be experienced. Conversely, if the flow balance is forced, the impact on the power generation is represented approximately by the amount of peaking power generation lost, and there would be little or no drawdown of the pool. Thirdly, the purpose of the release requirement is to protect and maintain the fishery. If the release is inadequate for that purpose, nothing has been gained and there could be an adverse impact on other uses.

TABLE 113 - SUPPLEMENTAL INFORMATION ON POWER GENERATION

RELEASE REQUIREMENT	BALTIMORE WITHDRAWAL	GENERATION AVAILABLE PREDRAWDOWN AS % OF TOTAL GENERATION SIMULATED	PREDRAWDOWN POWER GENERATION LOSS			POST DRAW-DOWN GENERATION LOST (CFS DAYS)	TOTAL GENERATION LOST AS PERCENT OF TOTAL POSSIBLE GENERATION
			AMOUNT OF LOSS (CFS DAYS)	TOT. POWER GENERATED BASE CASE (CFS DAYS)	% LOSS		
2500 cfs March Through June, Zero Remainder of Year.	100 cfs	94.7	3062550	40182311	7.6	2244468	12.5
5000 cfs March Through June, Zero Remainder of Year.	155 cfs	85.7	5076432	36368449	14.0	6058330	26.4
5000 cfs March Through June, Zero Remainder of Year.	388 cfs	85.4	5461522	36246332	15.1	6180447	27.4
2500 cfs Year Round	155 cfs	74.9	4203346	31779029	13.2	10647750	35.0
5000 cfs Year Round	155 cfs	67.3	5992806	28595018	21.0	13831761	46.7
5000 cfs Year Round Except When Inflow Less Than 5000 cfs Release Net Inflow	388 cfs	67.1	6185804	28455888	21.7	13970891	47.5
15000 cfs March Through May, 5000 cfs Remainder of Year.	0	45.2	8815718	23265292	37.9	19161487	65.9

TABLE 114

RANKING OF FIXED RELEASE SCHEMES
BY NUMBER OF DEFICITS BELOW
ELEVATION 107.2 FT.MSL

RELEASE REQUIREMENT SPRING	RELEASE REQUIREMENT OTHER	BALTIMORE WITHDRAWAL	NO. OF DEFICITS
2500	0	100 cfs	399
5000	0	155 cfs	438
5000	0	388 cfs	440
2500	2500 Net	0	450
2500	2500	155 cfs	452
2500	2500 Net	388 cfs	455
5000	5000	155 cfs	481
5000	5000 Net	155 cfs	481
5000	5000 Net	388 cfs	483
5000	5000	388 cfs	483
5000	Net	388 cfs	483
15000	5000	0	504
15000	5000 Net	0	504
15000	5000 Net	388 cfs	508

KEY: Spring means release requirement during period March through June (March through May for 15000 cfs release.) Other means release requirement during period other than spring. Net means when inflow is less than the release requirement shown under OTHER, the net inflow becomes the release requirement

TABLE 115

RANKING OF FIXED RELEASE SCHEMES
BY NUMBER OF DEFICITS BELOW
ELEVATION 99.2 FT.MSL

RELEASE REQUIREMENT		BALTIMORE	NO. OF
SPRING	OTHER	WITHDRAWAL	DEFICITS
2500	0	100 cfs	202
5000	0	155 cfs	642
5000	0	388 cfs	669
2500	2500 Net	0	1063
2500	2500	155 cfs	1087
2500	2500 Net	388 cfs	1108
5000	5000 Net	155 cfs	1528
5000	5000	155 cfs	1528
5000	5000 Net	388 cfs	1538
5000	5000	388 cfs	1538
5000	Net	388 cfs	1546
15000	5000 Net	0	1646
15000	5000	0	1646
15000	5000 Net	388 cfs	1678

KEY: Same as Table 114.

The effect of the Baltimore withdrawal seems fairly small. For example, consider cases 13 and 14 in Table 112. The release requirement is the same for both cases, but the Baltimore withdrawal increases from zero to 250 mgd (388 cfs). The increased withdrawal increases the number of deficits below elevation 99.2 from 1063 to 1108, or an increase of 45 days out of the 3430 days simulated. Similarly, cases 3 and 4 in Table 112 show that an increase of Baltimore withdrawal from 100 mgd to 250 mgd results in an increase of 27 days in the number of deficits below elevation 99.2. That increased withdrawal results in a loss of an additional 1% of the power generated during the spring and early summer. In fact, it appears that as the release requirement becomes more severe, the incremental effect of the Baltimore withdrawal decreases, at least in terms of number of deficits below elevation 99.2.

Note also that releasing the net inflow whenever the inflow is less than the power generation does not change the number of deficits or the amount of power generation lost by very much. Consider, for example, cases 6 and 9 in Table 112. There is no change in the number of deficits below elevations 107.2 and 99.2. Thus, it appears that the deficits are not caused by flow augmentation but by the existing operating procedures and the lack of flow balance in the simulations.

2. Comparison of Fixed Minimum Pool Elevation Schemes

Table 116 presents a summary of the number of deficits below specified elevations, the minimum pool elevations, and the maximum and minimum releases for the fixed elevation schemes.

Generally, the number of deficits do not appear to be very different among schemes. The schemes with target elevation of 107.2 always have a large number of deficits below that elevation but that is due largely to effects of Muddy Run. These schemes do not have any deficits below 102.0 or 99.2. The schemes with target elevation of 102.0 have fewer deficits below 107.2 than do the schemes with the 107.2 target. There are very few deficits below the target elevation for schemes with a target elevation of 102.0 or 99.2.

The schemes with lower target elevations have lower minimum pool elevations as expected.

In general, these schemes are somewhat similar to current operating procedures and thus would be expected to have little effect on power generation.

The major reason for requiring a minimum release at Conowingo is to protect and enhance the fishery. In the past, power operations have caused kills of anadromous fish, in part due to plant shutdowns. If plant shutdown is permitted, the fish kills will

TABLE 116 - SUMMARY OF NUMBER OF DEVICITS AND OUTFLOWS FOR FIXED ELEVATION REQUIREMENT

TARGET ELEVATION FEET MSL	BALTIMORE WITHDRAWAL	NUMBER OF DEFICITS (DAYS) BELOW ELEVATION SHOWN			MINIMUM POOL ELEVATION	MAX. OUTFLOW ANY YEAR (CFS)	MIN. OUTFLOW ANY YEAR (CFS)
		107.2	102.0	99.2			
102.0	100 CFS	356	16	---	101.51	1,039,747	-2123
99.2	100 CFS	356	--	2	98.98	1,039,747	438
107.2	100 CFS	570	--	---	106.04	1,039,747	-2026
99.2	500 MGD (774 CFS)	370	--	4	98.76	1,039,073	350
107.2	250 MGD (388 CFS)	563	--	---	106.06	---	---
102.0	250 MGD (388 CFS)	362	6	---	101.36	---	---
99.2	250 MGD (388 CFS)	362	--	2	98.87	---	---
107.2	500 MCD (774 CFS)	571	--	---	106.09	---	---

occur again in the future especially during anadromous fish runs. The diurnal fluctuations of releases were not simulated and thus the overnight shutdown condition can be addressed only indirectly by considering the computed release to be a constant average daily flow. This in effect requires that under certain conditions the power plant would be operated so as to release a constant flow equal in daily volume to that which would be otherwise released at variable rates over the daily period under the specified conditions. The major problem is to establish the conditions under which this change would be required and that problem has not been addressed.

The important question is whether any of these schemes will enhance the fishery. The lowest computed release is less than 2,500 cfs during either May or June in many years, and the tabulations of minimum flows show negative values, created by the operation of Muddy Run, during some months of the year. These schemes will allow shutdown a substantial part of the time. Therefore, it is questionable whether any of these schemes will protect the fishery.

F. Storage Yield Analysis

As a result of the analyses described previously some questions were raised regarding the amount of water that could be obtained from storage at Conowingo. In order to answer those questions, a storage yield analysis was performed by assuming a certain gross rate of withdrawal of water for water supply purposes and determining the amount of storage required to sustain that rate of withdrawal during the most severe drought of record. The period of time from the beginning of drawdown of the reservoir to the end of drawdown for this most severe condition is called the critical period. Different gross rates of withdrawal were assumed and a curve was plotted showing the amount of storage required to supply a given draft rate. In this analysis the flow record at Harrisburg was used but the flows were multiplied by a factor of 1.124 which is the ratio of drainage area at Harrisburg to that at Conowingo. The reason for using Harrisburg data is that there are inconsistencies between Harrisburg and Marietta flows and the Harrisburg data appears to be more reliable. Also, Harrisburg has a much longer record which spans both the 1961-66 and 1930-31 drought periods.

The storage yield analysis shows that during the most critical period (Aug. 11 to Nov. 26, 1964) an average outflow equal to 4,250 cfs could be obtained from Conowingo if all the storage were used. However, the average inflow during this period is 2,460 cfs so that the increment of release provided from storage is equivalent to 1,790 cfs.

If only the increment of storage between elevation 109.2 ft. msl and 99.2 ft. msl is used, the critical period is from

Aug. 30 to Nov. 25, 1964 and the average outflow is 2,890 cfs. The average inflow for this period is 2,260 cfs and the increment of release provided from storage is equivalent to 630 cfs. This analysis shows that it is not possible to obtain the minimum releases of the order of 3,500 cfs from the storage in the Conowingo pool, without a significant impact on other uses of the pool.

G. Simulation of Release Requirements Based on Natural Flow Conditions

1. Purpose and Schemes Considered

The pre-construction historic cycle of flows in the lower river reach apparently sustained a viable and plentiful fishery resource. A significant decline in the total fishery resource has occurred since construction of the hydropower dams in the lower Susquehanna River. Therefore, the simulation analyses included an evaluation of the effects of "natural" flows on hydropower generation and/or pool elevations at Conowingo through consideration of the following schemes:

a. Release the net inflow each day for the entire year.

b. Release the net inflow on each day during the anadromous spawning period (March 1st through June 30th) of each year. For each of the other eight months, set the minimum release equal to either of the following:

1) Mean average monthly flow for the period; or

2) Lowest average monthly flow for the period.

c. Minimum release equal to the minimum average monthly flow for each month for the period being simulated.

The discharge values used are shown in Table 117.

The Chester Water Authority, Peach Bottom and natural evaporative withdrawals plus a projected Baltimore City withdrawal of 388 cfs (250 mgd) were used. The base case is described on page 91. Two different periods were simulated. The first is the 14-year period from January 1961 through December 1974, used in the previous simulations. The inflow is the gaged flows at Marietta, Pa. for this period.

The second is the period January 1, 1891 through December 31, 1927. This period was chosen to evaluate the effects of using flows for the period of "best" fishery conditions. The inflow is the gaged flow at Harrisburg, Pa. for this period.

TABLE 117

MONTHLY FLOWS FOR SIMULATING NATURAL FLOW CONDITIONS

MONTH	1961-1974 MINIMUM AVERAGE MONTHLY FLOWS (CFS)	1961-1974 MEAN AVERAGE MONTHLY FLOWS (CFS)	1891-1927 MEAN AVERAGE MONTHLY FLOWS (CFS)
Jan.	10610	30321	38842
Feb.	15800	44022	42420
March	29190	79576	83146
Apr.	34870	76566	69812
May	29000	47220	44321
June	9182	33263	26996
July	3957	15695	16886
Aug.	3627	10150	14042
Sept.	2296	8772	12789
Oct.	2699	10418	18801
Nov.	3041	26502	25386
Dec.	8466	41480	33001

2. Program Modifications

The program described in section IV.D.1 was used with the following modifications:

a. The entire 12-month period for each calendar year was simulated.

b. The operating curves were modified so as to maintain flow balance for a given inflow. The procedure for the modification will be described subsequently.

c. The power generation capability was computed using a modified version of the fundamental equation

$$E_t = \frac{\eta Q \gamma H}{550} \qquad \ldots(7)$$

where E_t is the energy generated, in horsepower, by a flow of Q cfs falling through a net head of H feet, and η and γ are the efficiency of the turbines and the unit weight of water (62.4 lbs./cu.ft.), respectively. The value of H was computed by subtracting the tailwater elevation, obtained from the tailwater rating curve at the average daily discharge from the end-of-day elevation of the pool. The power generation was computed for each day and summed over each month of each year.

The amount of peaking power generation lost was computed by assuming for each of the three continuous release schemes that the value of Q to be used in the calculation was the value of the required release. In effect then equation (7) can be expanded to read:

$$E_t = E_{pt} + E_{bt} = \frac{\eta Q_p \gamma H}{550} + \frac{\eta Q_B \gamma H}{550} \qquad \ldots(8)$$

where Q_p is the flow used for peaking power generation and Q_B is the flow used for base load generation. Then three cases may arise:

a. The inflow exceeds 86000 cfs, Q_p=0, Q=Q_B= 86000 cfs.

b. Inflow less than 86000 cfs, but greater than the required release, Q_B is equal to the required release and Q_p is established by the operating curves discussed subsequently.

c. Inflow less than the established release, Q_p=0, Q_B is equal to net inflow.

The operating curves as originally defined were based on current operations under specified inflows. It was assumed

that those operating curves represented typical amounts of peaking power that would be generated under the specified inflows. If the release requirement is imposed, and inflow is less than this release, the release will be equal to the net inflow, which is then a 45^{o} line when outflow is plotted against inflow. When inflow is greater than the required release the amount of peaking power generated was assumed to be equal to the amount of peaking power that would be generated at an inflow equal to the actual inflow minus the withdrawals and the release. The concept is shown schematically in Figure 32. However, at inflow of 86000 cfs all units will be running at full capacity so that the operating curves must still pass through the 86000 cfs on both inflow and outflow axes.

3. Simulations for Period 1961-74

a. Base Case

The results for the base case are described in Section IV.D.4.a., p. 91, and the results are shown in Tables 132, 133 and 134.

b. Release Equal to Daily Net Inflow for Entire Year

Table 118 shows the number of occurrences of pool elevation below 107.2 feet msl on weekends. Table 119 shows the number of occurrences of pool elevations below 99.2 feet msl. Table 120 shows the minimum pool elevations by month and year. There are 49 occurrences of pool elevations below 107.2 feet msl, but there are no occurrences of elevations below 99.2 feet msl. The minimum pool elevations are all above 106 feet msl.

This scheme results in losing all peaking power generation. Since the outflow is essentially equal to the inflow, the power generated must be all base load generation.

c. Continuous Release Equal to Daily Net Inflow March Through June; Mean Average Monthly Flow Remainder of Year

The number of occurrences of pool elevations below 107.2 feet msl are shown in Table 121. The number of occurrences below elevation 99.2 feet msl are shown in Table 122. The minimum pool elevations are shown in Table 123. The months in which there is no peaking power generated under this scheme are shown in Table 124. For the 14 years simulated there are 10 years in which no peaking power would be possible in at least one month and in 5 years, there are at least 3 months in which no peaking power would be generated, exclusive of the four run-of-river operating months.

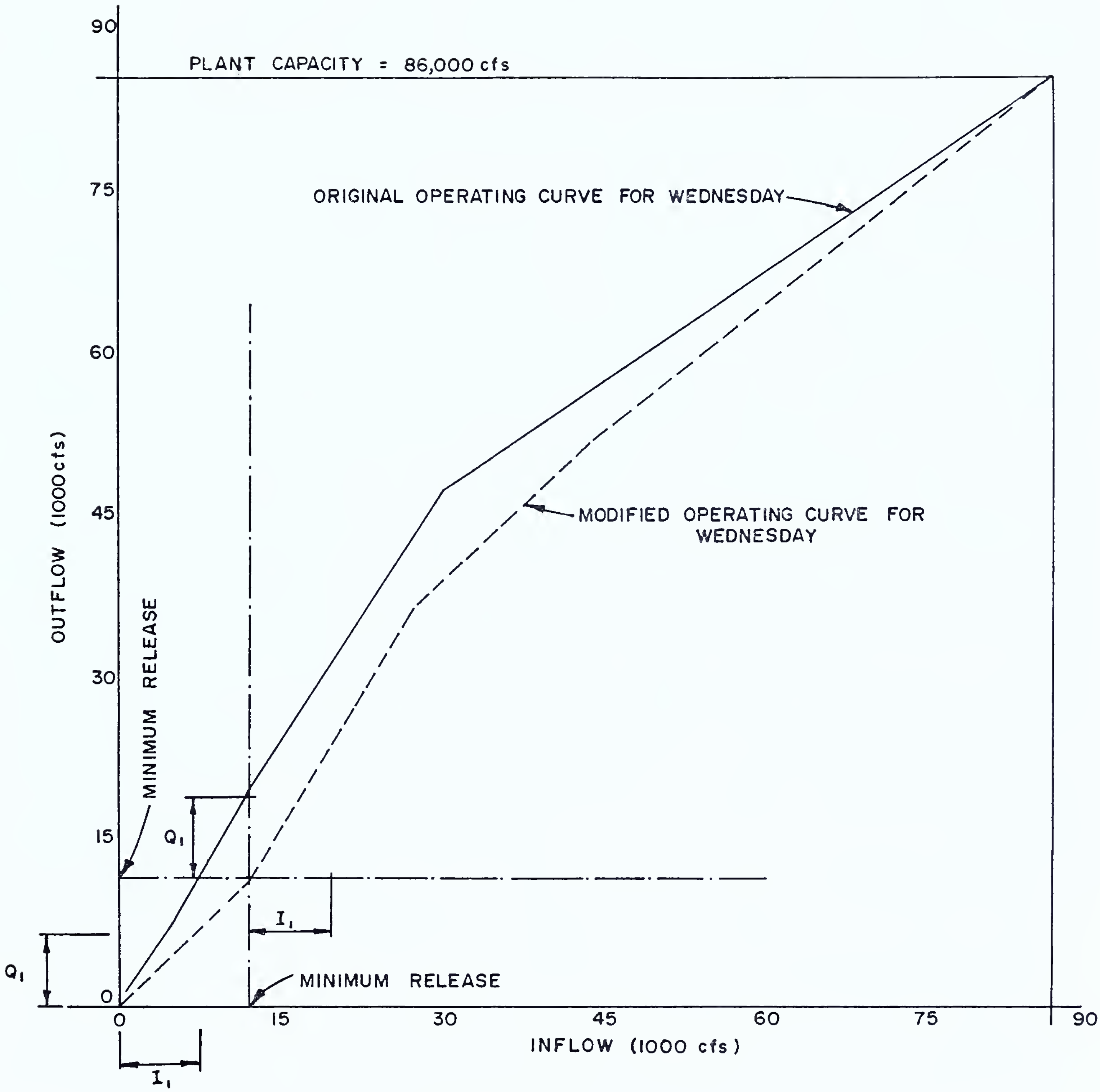

FIGURE 32
SCHEMATIC OF MODIFICATION OF OPERATING CURVES
FOR EFFECT OF MINIMUM RELEASE ON A WEEKDAY

TABLE 118 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL
MINIMUM RELEASE = NET INFLOW YEAR ROUND,
BALTIMORE WITHDRAWAL = 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	4	5	4	0	0	0	13
1963	0	0	0	0	0	0	0	3	5	0	0	0	8
1964	0	0	0	0	0	0	1	4	4	0	0	0	9
1965	0	0	0	0	0	0	3	4	4	0	0	0	11
1966	0	0	0	0	0	0	3	3	2	0	0	0	8
1967	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	11	19	19	0	0	0	49

TABLE 119 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL
MINIMUM RELEASE = NET INFLOW YEAR ROUND,
BALTIMORE WITHDRAWAL = 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 120 -- MINIMUM POOL ELEVATIONS
MINIMUM RELEASE = NET INFLOW,
BALTIMORE WITHDRAWAL = 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1961	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	106.17	106.17	107.23
1962	107.23	107.23	107.23	107.23	107.23	107.23	106.17	106.17	106.17	107.23	107.23	107.23
1963	107.23	107.23	107.23	107.23	107.23	107.23	107.23	106.17	106.17	106.17	106.17	107.23
1964	107.23	107.23	107.23	107.23	107.23	107.23	106.17	106.17	106.17	106.17	106.17	107.23
1965	107.23	107.23	107.23	107.23	107.23	107.23	106.17	106.17	106.17	107.23	107.23	107.23
1966	107.23	107.23	107.23	107.23	107.23	107.23	106.17	106.17	106.17	106.17	107.23	107.23
1967	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23
1968	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23
1969	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	106.17	106.17	107.23	107.23
1970	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23
1971	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23
1972	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23
1973	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23
1974	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23

TABLE 121 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL, MINIMUM RELEASE = NET INFLOW MARCH - JUNE, RELEASE = AVERAGE MONTHLY FLOW REST OF YEAR BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1961	0	0	0	0	0	0	4	2	4	0	0	0	10
1962	0	0	0	0	0	0	5	4	5	0	0	0	14
1963	0	0	0	0	0	0	4	4	5	0	0	0	13
1964	0	0	0	0	0	0	4	5	4	0	0	0	13
1965	0	0	0	0	0	0	4	5	4	0	0	0	13
1966	0	0	0	0	0	0	5	4	4	0	0	0	13
1967	0	0	0	0	0	0	6	7	9	0	0	0	22
1968	0	0	0	0	0	0	5	4	7	0	0	0	16
1969	0	0	0	0	0	0	4	10	8	0	0	0	22
1970	0	0	0	0	0	0	1	4	4	0	0	0	9
1971	0	0	0	0	0	0	4	9	8	0	0	0	21
1972	0	0	0	0	0	0	2	8	9	0	0	0	19
1973	0	0	0	0	0	0	3	3	6	0	0	0	12
1974	0	0	0	0	0	0	6	3	9	0	0	0	18
TOTAL	0	0	0	0	0	0	57	72	86	0	0	0	215

TABLE 122 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL, MINIMUM RELEASE = NET INFLOW MARCH - JUNE, RELEASE = AVERAGE MONTHLY FLOW REST OF YEAR BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	3	0	0	0	0	0	0	0	0	0	0	3
1963	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	4	4
1968	14	0	0	0	0	0	0	0	0	0	0	0	14
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	2	0	2
1971	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	14	3	0	0	0	0	0	0	0	0	2	4	23

TABLE 123 -- MINIMUM POOL ELEVATIONS, MINIMUM RELEASE = NET INFLOW MARCH - JUNE, RELEASE = AVERAGE MONTHLY FLOW REST OF YEAR BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1961	106.17	106.17	107.23	107.23	107.23	107.23	106.17	105.93	105.36	105.36	105.36	105.36
1962	100.18	99.09	107.23	107.23	107.23	107.23	106.17	106.17	106.15	102.52	102.52	103.45
1963	101.01	101.01	101.01	107.23	107.23	107.23	106.17	106.17	106.17	106.17	106.17	106.17
1964	106.17	106.17	107.23	107.23	107.23	107.23	106.17	106.17	106.17	106.17	106.17	106.17
1965	103.71	103.71	107.23	107.23	107.23	107.23	106.17	106.17	106.17	105.55	105.55	105.55
1966	105.55	106.17	107.23	107.23	107.23	107.23	106.17	106.17	106.17	106.17	106.17	102.67
1967	102.67	104.53	107.23	107.23	107.23	107.23	106.05	103.58	102.59	102.36	103.11	97.13
1968	97.13	100.33	107.23	107.23	107.23	107.23	105.21	105.36	104.10	104.10	99.72	105.32
1969	103.66	102.89	107.23	107.23	107.23	107.23	102.88	102.52	102.77	102.77	98.28	101.04
1970	103.62	103.62	107.23	107.23	107.23	107.23	106.17	105.75	106.17	106.09	105.88	105.20
1971	104.27	104.27	107.23	107.23	107.23	107.23	106.17	103.69	104.64	103.46	104.37	103.76
1972	104.74	104.47	107.23	107.23	107.23	107.23	106.04	104.13	104.16	104.16	104.16	104.56
1973	102.23	104.52	107.23	107.23	107.23	107.23	106.17	105.87	105.58	103.53	102.71	105.90
1974	106.38	105.25	107.23	107.23	107.23	107.23	104.94	106.17	102.43	101.21	101.21	101.73

TABLE 124

MONTHS WITH NO PEAKING
POWER GENERATION
SCHEME 3c

1961	October, November and December
1962	July and September
1963	February and July through December
1964	July through December
1965	July, August, September, November and December
1966	July, August, September and October
1968	January and August
1969	September and October
1970	January
1972	October

d. Release Equal to Daily Net Inflow March Through June Lowest Average Monthly Flow Remainder of Year

The number of occurrences of pool elevations below 107.2 feet msl are shown in Table 125. The number of occurrences of pool elevations below 99.2 feet msl are shown in Table 126. The minimum pool elevations are shown in Table 127. Under this scheme peaking power could be generated in all months.

e. Continuous Release Equal to Minimum Average Monthly Flow Entire Year

The number of occurrences of pool elevations below 107.2 feet msl and 99.2 feet msl are shown in Tables 128 and 129, respectively. Minimum pool elevations are shown in Table 130.

4. Simulations For Period 1891 Through 1927

a. Base Case

The number of occurrences of pool elevation less than 107.2 and 99.2 feet msl are shown in Tables 131 and 132, respectively. The minimum pool elevations are shown in Table 133. Note there are only three cases where the pool elevation is less than 99.2 feet msl and these occur in December 1899.

b. Release Equal to Daily Net Inflow for Entire Year

The number of occurrences of pool elevations less than 107.2 and 99.2 feet msl are shown in Tables 143 and 135, respectively. Minimum pool elevations are shown in Table 136. There is no peaking power generation under this scheme.

c. Release Equal to Daily Net Inflow March Through June; Mean Average Monthly Flow Remainder of Year

The number of occurrences of pool elevations less than 107.2 and 99.2 feet msl are shown in Tables 137 and 138, respectively. Minimum pool elevations are shown in Table 139. Note there are only six occurrences of minimum pool elevation less than 99.2 for this case.

The months during which no peaking power would be generated are shown in Table 140 and is exclusive of the March through June period of run-of-river operation.

TABLE 125 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL
MINIMUM RELEASE = NET INFLOW MARCH - JUNE, RELEASE
MONTHLY MINIMUM REST OF YEAR, BALTIMORE WITHDRAWAL
250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1961	0	0	0	0	0	0	0	2	4	0	0	0	[illegible]
1962	0	0	0	0	0	0	5	4	5	0	0	0	1[illegible]
1963	0	0	0	0	0	0	4	4	4	0	0	0	1[illegible]
1964	0	0	0	0	0	0	4	5	4	0	0	0	1[illegible]
1965	0	0	0	0	0	0	4	5	6	0	0	0	1[illegible]
1966	0	0	0	0	0	0	5	4	2	0	0	0	1[illegible]
1967	0	0	0	0	0	0	2	8	9	0	0	0	1[illegible]
1968	0	0	0	0	0	0	2	4	5	0	0	0	1[illegible]
1969	0	0	0	0	0	0	1	2	4	0	0	0	[illegible]
1970	0	0	0	0	0	0	0	6	3	0	0	0	[illegible]
1971	0	0	0	0	0	0	4	2	3	0	0	0	[illegible]
1972	0	0	0	0	0	0	0	5	9	0	0	0	1[illegible]
1973	0	0	0	0	0	0	6	6	4	0	0	0	1[illegible]
1974	0	0	0	0	0	0	1	5	6	0	0	0	1[illegible]
TOTAL	0	0	0	0	0	0	38	62	68	0	0	0	168

TABLE 126 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL
MINIMUM RELEASE = NET INFLOW MARCH - JUNE, RELEASE
MONTHLY MINIMUM REST OF YEAR, BALTIMORE WITHDRAWAL
250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 127 -- MINIMUM POOL ELEVATIONS
MINIMUM RELEASE = MONTHLY MINIMUMS YEAR ROUND
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1961	105.28	105.28	107.23	107.23	107.23	107.23	107.43	105.76	105.36	105.39	104.14	100.64
1962	101.15	103.46	107.23	107.23	107.23	107.23	106.10	106.10	105.56	104.05	104.28	104.90
1963	104.67	102.26	102.26	107.23	107.23	107.23	105.81	105.67	105.43	105.38	105.34	104.74
1964	104.36	104.55	107.23	107.23	107.23	107.23	105.58	105.48	106.03	106.12	106.15	104.94
1965	102.02	100.90	107.23	107.23	107.23	107.23	106.05	105.27	104.85	104.28	102.21	102.30
1966	101.52	101.83	107.23	107.23	107.23	107.23	106.14	106.14	106.17	105.33	104.73	104.33
1967	104.68	103.75	106.22	107.23	107.23	107.23	104.71	102.51	102.16	102.11	100.57	106.18
1968	104.54	104.23	107.23	107.23	107.23	107.23	106.24	105.97	105.64	104.30	104.31	104.95
1969	104.76	104.05	107.23	107.23	107.23	107.23	104.92	105.71	105.75	105.70	105.26	103.61
1970	102.02	102.63	107.23	107.23	107.23	107.23	105.20	105.69	106.06	104.30	102.97	106.39
1971	105.29	105.29	107.23	107.23	107.23	107.23	106.32	106.01	104.75	103.88	104.13	104.94
1972	105.21	104.51	107.23	107.23	107.23	107.23	106.03	105.36	105.14	104.87	103.54	107.23
1973	105.08	106.33	107.23	107.23	107.23	107.23	104.89	103.65	105.41	104.81	103.04	101.31
1974	106.07	105.52	107.23	107.23	107.23	107.23	105.47	105.81	103.06	103.18	102.91	102.84

TABLE 128 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FEET MSL
MINIMUM RELEASE = MONTHLY MINIMUMS YEAR ROUND
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1961	0	0	0	0	2	2	0	2	4	0	0	0	10
1962	0	0	0	0	3	4	5	4	5	0	0	0	21
1963	0	0	0	0	8	10	8	9	9	0	0	0	44
1964	0	0	0	0	3	7	8	10	8	0	0	0	36
1965	0	0	0	0	6	8	9	9	8	0	0	0	40
1966	0	0	0	0	5	8	10	8	8	0	0	0	39
1967	0	0	0	0	3	2	7	8	9	0	0	0	29
1968	0	0	0	0	2	5	7	9	7	0	0	0	30
1969	0	0	0	0	9	8	8	9	8	0	0	0	42
1970	0	0	0	0	5	2	4	6	3	0	0	0	20
1971	0	0	0	0	7	8	9	9	8	0	0	0	41
1972	0	0	0	0	0	0	0	4	9	0	0	0	13
1973	0	0	0	0	0	1	7	8	5	0	0	0	21
1974	0	0	0	0	5	8	7	9	9	0	0	0	38
TOTAL	0	0	0	0	58	73	89	104	100	0	0	0	424

TABLE 129 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL
MINIMUM RELEASE = MONTHLY MINIMUM YEAR ROUND
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	2	3	19	13	18	17	24	12	108
1964	3	0	0	0	0	0	0	0	0	0	0	0	3
1965	0	0	0	0	0	0	0	0	0	2	10	21	33
1966	28	9	0	0	0	16	24	21	11	30	30	24	193
1967	31	17	3	0	0	0	0	0	0	0	0	0	51
1968	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	3	8	6	8	12	25	5	67
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	62	26	3	0	2	22	51	40	37	61	89	62	455

TABLE 130 -- MINIMUM POOL ELEVATIONS
MINIMUM RELEASE = MONTHLY MINIMUMS YEAR ROUND
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1961	105.28	105.28	106.45	105.28	104.63	104.48	107.20	105.76	105.36	105.39	104.14	100.64
1962	101.15	103.46	102.82	105.49	105.51	106.15	106.08	106.08	105.56	104.05	104.28	104.90
1963	104.67	102.26	102.26	103.09	98.60	98.15	97.09	96.93	96.66	96.61	96.57	96.21
1964	98.33	104.55	104.55	105.59	106.17	104.27	103.31	103.20	103.79	103.87	103.91	103.50
1965	100.58	99.40	106.64	105.35	102.75	101.16	101.01	100.24	99.80	99.15	96.84	96.94
1966	96.66	96.41	105.68	103.52	102.79	95.54	96.16	96.16	96.73	95.89	95.21	94.76
1967	95.59	96.56	96.56	106.40	105.72	105.52	103.72	101.53	101.17	101.13	99.53	106.18
1968	104.54	104.23	104.65	105.64	105.64	104.81	104.10	104.06	104.44	103.33	103.34	104.35
1969	104.76	104.05	101.51	103.61	100.59	103.97	103.22	104.00	104.58	104.53	104.42	103.61
1970	102.02	102.88	104.86	107.23	103.88	105.56	104.50	105.69	106.06	104.30	102.97	105.39
1971	105.29	105.29	106.47	104.45	101.03	98.13	98.07	98.26	96.98	96.01	95.29	97.20
1972	105.21	104.51	106.54	105.71	105.91	105.48	106.03	105.36	105.14	104.87	103.54	107.23
1973	105.08	106.33	103.40	103.84	106.83	105.27	104.10	102.86	105.01	104.50	102.73	101.00
1974	106.07	105.52	105.24	104.60	103.99	103.07	103.90	104.25	102.06	102.18	101.91	101.85

TABLE 131 - NUMBER OF DEFICITS BELOW ELEVATION 107.2 FEET MSL,
NO MINIMUM RELEASE
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1891	0	0	0	0	0	1	5	10	4	0	0	0	20
1892	0	0	0	0	0	3	1	0	3	0	0	0	7
1893	0	0	0	0	2	2	1	4	6	0	0	0	15
1894	0	0	0	0	0	0	5	0	8	0	0	0	13
1895	0	0	0	0	1	1	0	0	0	0	0	0	2
1896	0	0	0	0	0	4	8	10	8	0	0	0	30
1897	0	0	0	0	2	2	3	8	8	0	0	0	23
1898	0	0	0	0	3	2	0	3	4	0	0	0	12
1899	0	0	0	0	5	8	10	8	9	0	0	0	40
1900	0	0	0	0	0	0	1	3	4	0	0	0	8
1901	0	0	0	0	0	0	0	0	1	0	0	0	1
1902	0	0	0	0	0	0	0	0	1	0	0	0	1
1903	0	0	0	0	0	2	6	2	0	0	0	0	10
1904	0	0	0	0	4	8	10	6	0	0	0	0	28
1905	0	0	0	0	1	4	10	7	9	0	0	0	31
1906	0	0	0	0	0	0	6	6	5	0	0	0	17
1907	0	0	0	0	5	2	5	8	3	0	0	0	23
1908	0	0	0	0	3	0	1	9	8	0	0	0	21
1909	0	0	0	0	0	0	2	7	5	0	0	0	14
1910	0	0	0	0	5	8	10	8	8	0	0	0	39
1911	0	0	0	0	0	7	9	8	8	0	0	0	32
1912	0	0	0	0	0	4	5	7	7	0	0	0	23
1913	0	0	0	0	0	5	5	0	3	0	0	0	13
1914	0	0	0	0	0	0	7	6	7	0	0	0	20
1915	0	0	0	0	1	7	1	7	1	0	0	0	17
1916	0	0	0	0	4	2	1	7	4	0	0	0	18
1917	0	0	0	0	1	2	3	6	10	0	0	0	22
1918	0	0	0	0	4	8	8	10	7	0	0	0	37
1919	0	0	0	0	0	0	1	3	8	0	0	0	12
1920	0	0	0	0	2	4	9	5	8	0	0	0	28
1921	0	0	0	0	2	2	0	5	5	0	0	0	14
1922	0	0	0	0	1	0	0	2	5	0	0	0	8
1923	0	0	0	0	2	5	8	9	9	0	0	0	33
1924	0	0	0	0	0	2	1	8	3	0	0	0	14
1925	0	0	0	0	2	1	0	5	5	0	0	0	13
1926	0	0	0	0	0	5	7	4	2	0	0	0	18
1927	0	0	0	0	4	0	5	8	9	0	0	0	26
TOTAL	0	0	0	0	54	101	154	199	195	0	0	0	703

TABLE 132 - NUMBER OF DEFICITS BELOW ELEVATION 99.2 FEET MSL,
NO MINIMUM RELEASE
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1891	0	0	0	0	0	0	0	0	0	0	0	0	0
1892	0	0	0	0	0	0	0	0	0	0	0	0	0
1893	0	0	0	0	0	0	0	0	0	0	0	0	0
1894	0	0	0	0	0	0	0	0	0	0	0	0	0
1895	0	0	0	0	0	0	0	0	0	0	0	0	0
1896	0	0	0	0	0	0	0	0	0	0	0	0	0
1897	0	0	0	0	0	0	0	0	0	0	0	0	0
1898	0	0	0	0	0	0	0	0	0	0	0	0	0
1899	0	0	0	0	0	0	0	0	0	0	0	3	3
1900	0	0	0	0	0	0	0	0	0	0	0	0	0
1901	0	0	0	0	0	0	0	0	0	0	0	0	0
1902	0	0	0	0	0	0	0	0	0	0	0	0	0
1903	0	0	0	0	0	0	0	0	0	0	0	0	0
1904	0	0	0	0	0	0	0	0	0	0	0	0	0
1905	0	0	0	0	0	0	0	0	0	0	0	0	0
1906	0	0	0	0	0	0	0	0	0	0	0	0	0
1907	0	0	0	0	0	0	0	0	0	0	0	0	0
1908	0	0	0	0	0	0	0	0	0	0	0	0	0
1909	0	0	0	0	0	0	0	0	0	0	0	0	0
1910	0	0	0	0	0	0	0	0	0	0	0	0	0
1911	0	0	0	0	0	0	0	0	0	0	0	0	0
1912	0	0	0	0	0	0	0	0	0	0	0	0	0
1913	0	0	0	0	0	0	0	0	0	0	0	0	0
1914	0	0	0	0	0	0	0	0	0	0	0	0	0
1915	0	0	0	0	0	0	0	0	0	0	0	0	0
1916	0	0	0	0	0	0	0	0	0	0	0	0	0
1917	0	0	0	0	0	0	0	0	0	0	0	0	0
1918	0	0	0	0	0	0	0	0	0	0	0	0	0
1919	0	0	0	0	0	0	0	0	0	0	0	0	0
1920	0	0	0	0	0	0	0	0	0	0	0	0	0
1921	0	0	0	0	0	0	0	0	0	0	0	0	0
1922	0	0	0	0	0	0	0	0	0	0	0	0	0
1923	0	0	0	0	0	0	0	0	0	0	0	0	0
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0	0	0	0	0	0	0
1926	0	0	0	0	0	0	0	0	0	0	0	0	0
1927	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	0	0	0	0	3	3

TABLE 133 - MINIMUM POOL ELEVATIONS
NO MINIMUM RELEASE
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1891	105.46	107.23	107.23	106.36	105.16	104.89	103.24	101.79	104.00	102.99	102.70	103.00
1892	106.79	104.79	104.17	106.64	107.23	105.78	105.28	105.42	105.36	106.68	106.13	105.29
1893	106.50	105.01	105.58	106.96	106.37	105.23	104.80	105.58	102.64	104.18	103.47	103.52
1894	105.04	103.43	107.23	104.49	105.41	105.46	105.16	107.05	102.25	100.96	100.15	103.96
1895	103.71	105.23	106.67	107.11	105.41	105.68	105.62	107.54	107.67	107.18	106.38	104.55
1896	106.00	105.37	104.93	106.90	105.44	103.77	101.31	100.85	100.83	100.41	105.23	104.78
1897	105.53	105.24	107.23	106.48	106.17	105.04	105.85	103.15	103.76	103.46	100.55	103.32
1898	104.98	105.91	106.40	105.67	106.99	104.70	105.63	105.05	105.94	104.53	105.20	104.70
1899	105.95	105.11	107.09	106.51	103.32	102.67	103.26	100.97	100.72	100.32	99.32	98.89
1900	100.64	105.94	106.79	106.54	105.29	105.38	106.79	106.31	106.21	106.19	107.10	105.40
1901	105.36	106.33	107.22	105.72	106.69	106.67	105.59	106.15	105.30	104.30	105.28	105.43
1902	105.15	105.70	106.20	106.06	105.31	105.29	107.23	105.63	106.77	105.38	103.43	103.46
1903	105.15	106.42	106.55	105.21	105.41	104.76	103.76	104.31	105.47	106.44	105.33	105.14
1904	104.59	106.75	106.20	105.87	103.92	102.21	101.78	103.42	107.18	105.85	105.89	105.83
1905	103.48	105.29	104.90	105.71	105.11	101.84	101.59	101.82	101.81	100.32	99.36	99.75
1906	104.13	105.45	105.64	107.23	105.49	105.84	104.39	103.22	104.33	106.20	104.90	104.69
1907	106.23	105.65	105.47	106.11	104.91	105.49	104.69	105.81	103.92	103.06	103.37	104.64
1908	106.12	105.85	105.23	105.61	106.01	105.49	105.76	106.08	105.50	104.52	104.38	103.58
1909	99.23	105.91	104.71	105.07	105.64	105.36	105.35	105.87	105.69	105.56	105.46	102.89
1910	104.11	105.03	106.19	105.17	104.08	102.17	103.53	103.53	104.53	106.51	105.54	105.38
1911	106.41	105.48	105.64	106.53	105.43	102.87	103.96	104.27	101.42	106.20	105.38	105.43
1912	105.20	105.07	106.41	107.23	105.96	105.15	104.42	104.22	102.56	105.30	103.12	102.72
1913	102.77	105.20	105.16	106.21	105.25	104.95	104.83	107.24	105.52	103.16	104.18	105.27
1914	104.07	105.23	103.65	107.23	106.22	105.19	103.50	104.71	105.26	105.14	105.15	103.72
1915	104.00	107.05	105.99	105.24	105.22	103.66	105.13	102.83	104.93	103.95	104.64	105.31
1916	107.13	106.11	106.12	107.23	104.72	104.24	105.30	105.21	105.87	105.76	105.58	104.93
1917	104.35	103.92	103.86	105.93	105.26	105.56	105.72	101.96	102.19	102.47	105.12	104.79
1918	104.70	104.30	106.70	105.69	105.16	102.93	103.44	104.04	102.32	104.27	104.60	104.90
1919	105.09	104.92	106.75	106.56	106.33	105.23	105.28	104.38	104.89	104.55	105.51	106.28
1920	105.45	105.55	105.40	107.36	105.22	103.53	103.82	104.41	102.41	100.60	100.46	105.55
1921	105.43	103.53	105.21	106.12	105.09	105.86	106.24	105.17	104.37	104.63	102.98	106.46
1922	105.42	104.68	106.24	106.11	105.88	105.81	106.03	104.45	105.95	106.85	107.25	107.32
1923	104.64	104.08	103.74	105.77	105.51	104.60	103.56	102.07	102.73	101.39	101.31	100.52
1924	104.85	105.56	104.69	104.77	107.23	105.35	105.17	104.83	106.38	104.95	104.20	104.71
1925	104.65	104.42	106.13	105.61	105.43	105.56	105.59	105.16	104.95	106.03	104.67	105.22
1926	104.21	104.07	106.50	107.23	105.39	104.72	105.36	104.68	103.58	103.59	104.15	105.18
1927	105.13	105.79	107.23	106.09	105.07	105.24	104.35	103.05	102.27	101.62	106.04	107.08

TABLE 134 - NUMBER OF DEFICITS BELOW ELEVATION 107.2 FEET MSL,
MINIMUM RELEASE = NET INFLOW
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1891	0	0	0	0	0	0	0	0	0	0	0	0	0
1892	0	0	0	0	0	0	0	0	0	0	0	0	0
1893	0	0	0	0	0	0	0	3	0	0	0	0	3
1894	0	0	0	0	0	0	0	0	2	0	0	0	2
1895	0	0	0	0	0	0	0	1	2	0	0	0	3
1896	0	0	0	0	0	0	0	1	3	0	0	0	4
1897	0	0	0	0	0	0	0	0	0	0	0	0	0
1898	0	0	0	0	0	0	0	0	0	0	0	0	0
1899	0	0	0	0	0	0	0	1	0	0	0	0	1
1900	0	0	0	0	0	0	0	2	4	0	0	0	6
1901	0	0	0	0	0	0	0	0	0	0	0	0	0
1902	0	0	0	0	0	0	0	0	0	0	0	0	0
1903	0	0	0	0	0	0	0	0	0	0	0	0	0
1904	0	0	0	0	0	0	0	0	0	0	0	0	0
1905	0	0	0	0	0	0	0	0	0	0	0	0	0
1906	0	0	0	0	0	0	0	0	0	0	0	0	0
1907	0	0	0	0	0	0	0	1	0	0	0	0	1
1908	0	0	0	0	0	0	0	0	4	0	0	0	4
1909	0	0	0	0	0	0	0	3	4	0	0	0	7
1910	0	0	0	0	0	0	0	3	1	0	0	0	4
1911	0	0	0	0	0	0	0	2	0	0	0	0	2
1912	0	0	0	0	0	0	0	0	0	0	0	0	0
1913	0	0	0	0	0	0	0	2	3	0	0	0	5
1914	0	0	0	0	0	0	0	0	2	0	0	0	2
1915	0	0	0	0	0	0	0	0	0	0	0	0	0
1916	0	0	0	0	0	0	0	0	1	0	0	0	1
1917	0	0	0	0	0	0	0	0	0	0	0	0	0
1918	0	0	0	0	0	0	0	0	0	0	0	0	0
1919	0	0	0	0	0	0	0	0	0	0	0	0	0
1920	0	0	0	0	0	0	0	0	0	0	0	0	0
1921	0	0	0	0	0	0	0	0	1	0	0	0	1
1922	0	0	0	0	0	0	0	0	1	0	0	0	1
1923	0	0	0	0	0	0	2	2	0	0	0	0	4
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0	0	2	0	0	0	2
1926	0	0	0	0	0	0	0	0	0	0	0	0	0
1927	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	2	21	30	0	0	0	53

TABLE 135 - NUMBER OF DEFICITS BELOW ELEVATION 99.2 FEET MSL,
MINIMUM RELEASE = NET INFLOW
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1891	0	0	0	0	0	0	0	0	0	0	0	0	0
1892	0	0	0	0	0	0	0	0	0	0	0	0	0
1893	0	0	0	0	0	0	0	0	0	0	0	0	0
1894	0	0	0	0	0	0	0	0	0	0	0	0	0
1895	0	0	0	0	0	0	0	0	0	0	0	0	0
1896	0	0	0	0	0	0	0	0	0	0	0	0	0
1897	0	0	0	0	0	0	0	0	0	0	0	0	0
1898	0	0	0	0	0	0	0	0	0	0	0	0	0
1899	0	0	0	0	0	0	0	0	0	0	0	0	0
1900	0	0	0	0	0	0	0	0	0	0	0	0	0
1901	0	0	0	0	0	0	0	0	0	0	0	0	0
1902	0	0	0	0	0	0	0	0	0	0	0	0	0
1903	0	0	0	0	0	0	0	0	0	0	0	0	0
1904	0	0	0	0	0	0	0	0	0	0	0	0	0
1905	0	0	0	0	0	0	0	0	0	0	0	0	0
1906	0	0	0	0	0	0	0	0	0	0	0	0	0
1907	0	0	0	0	0	0	0	0	0	0	0	0	0
1908	0	0	0	0	0	0	0	0	0	0	0	0	0
1909	0	0	0	0	0	0	0	0	0	0	0	0	0
1910	0	0	0	0	0	0	0	0	0	0	0	0	0
1911	0	0	0	0	0	0	0	0	0	0	0	0	0
1912	0	0	0	0	0	0	0	0	0	0	0	0	0
1913	0	0	0	0	0	0	0	0	0	0	0	0	0
1914	0	0	0	0	0	0	0	0	0	0	0	0	0
1915	0	0	0	0	0	0	0	0	0	0	0	0	0
1916	0	0	0	0	0	0	0	0	0	0	0	0	0
1917	0	0	0	0	0	0	0	0	0	0	0	0	0
1918	0	0	0	0	0	0	0	0	0	0	0	0	0
1919	0	0	0	0	0	0	0	0	0	0	0	0	0
1920	0	0	0	0	0	0	0	0	0	0	0	0	0
1921	0	0	0	0	0	0	0	0	0	0	0	0	0
1922	0	0	0	0	0	0	0	0	0	0	0	0	0
1923	0	0	0	0	0	0	0	0	0	0	0	0	0
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0	0	0	0	0	0	0
1926	0	0	0	0	0	0	0	0	0	0	0	0	0
1927	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 136 - MINIMUM POOL ELEVATIONS
MINIMUM RELEASE = NET INFLOW
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1891	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23
1892	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	106.17	106.17	107.23
1893	106.17	107.23	107.23	107.23	107.23	107.23	107.23	106.17	107.23	107.23	107.23	107.23
1894	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	106.17	107.23	107.23	107.23
1895	107.23	107.23	107.23	107.23	107.23	107.23	107.23	106.17	106.17	106.17	106.17	107.23
1896	107.23	107.23	107.23	107.23	107.23	107.23	107.23	106.17	106.17	107.23	107.23	107.23
1897	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23
1898	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23
1899	107.23	107.23	107.23	107.23	107.23	107.23	107.23	106.17	107.23	106.17	107.23	107.23
1900	107.23	107.23	107.23	107.23	107.23	107.23	107.23	106.17	106.17	106.17	107.23	107.23
1901	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23
1902	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23
1903	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23
1904	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23
1905	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23
1906	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23
1907	107.23	107.23	107.23	107.23	107.23	107.23	107.23	106.17	106.71	107.23	107.23	107.23
1908	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	106.17	106.17	106.17	106.17
1909	107.23	107.23	107.23	107.23	107.23	107.23	107.23	106.17	106.17	106.17	106.17	106.17
1910	106.17	107.23	107.23	107.23	107.23	107.23	107.23	106.17	106.17	106.17	106.17	107.23
1911	107.23	107.23	107.23	107.23	107.23	107.23	107.23	106.17	107.23	107.23	107.23	107.23
1912	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23
1913	107.23	107.23	107.23	107.23	107.23	107.23	107.23	106.17	106.17	107.23	107.23	107.23
1914	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	106.17	106.17	106.17	106.17
1915	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23
1916	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	106.17	107.23	107.23	107.23
1917	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23
1918	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23
1919	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23
1920	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23
1921	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	106.17	107.23	107.23	107.23
1922	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	106.17	106.17	106.17	106.17
1923	107.23	107.23	107.23	107.23	107.23	107.23	106.17	106.17	107.23	106.17	107.23	107.23
1924	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23
1925	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	106.17	107.23	107.23	107.23
1926	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23
1927	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	107.23	106.17	107.23	107.23

TABLE 137 - NUMBER OF DEFICITS BELOW ELEVATION 107.2 FEET MSL, MINIMUM RELEASE = NET INFLOW MARCH - JUNE, RELEASE = AVERAGE MONTHLY FLOW REST OF YEAR, BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1891	0	0	0	0	0	0	1	3	8	0	0	0	12
1892	0	0	0	0	0	0	4	5	8	0	0	0	17
1893	0	0	0	0	0	0	5	4	4	0	0	0	13
1894	0	0	0	0	0	0	5	4	7	0	0	0	16
1895	0	0	0	0	0	0	8	9	9	0	0	0	26
1896	0	0	0	0	0	0	4	9	8	0	0	0	21
1897	0	0	0	0	0	0	4	6	8	0	0	0	18
1898	0	0	0	0	0	0	5	3	8	0	0	0	16
1899	0	0	0	0	0	0	5	4	9	0	0	0	18
1900	0	0	0	0	0	0	5	4	5	0	0	0	14
1901	0	0	0	0	0	0	4	4	1	0	0	0	9
1902	0	0	0	0	0	0	0	4	3	0	0	0	7
1903	0	0	0	0	0	0	3	4	3	0	0	0	10
1904	0	0	0	0	0	0	7	7	4	0	0	0	18
1905	0	0	0	0	0	0	8	5	7	0	0	0	20
1906	0	0	0	0	0	0	3	7	9	0	0	0	19
1907	0	0	0	0	0	0	3	5	4	0	0	0	12
1908	0	0	0	0	0	0	3	5	4	0	0	0	12
1909	0	0	0	0	0	0	4	5	4	0	0	0	13
1910	0	0	0	0	0	0	5	4	4	0	0	0	13
1911	0	0	0	0	0	0	5	4	2	0	0	0	11
1912	0	0	0	0	0	0	4	4	3	0	0	0	11
1913	0	0	0	0	0	0	4	5	4	0	0	0	13
1914	0	0	0	0	0	0	4	6	8	0	0	0	18
1915	0	0	0	0	0	0	3	8	8	0	0	0	19
1916	0	0	0	0	0	0	6	4	4	0	0	0	14
1917	0	0	0	0	0	0	2	7	4	0	0	0	13
1918	0	0	0	0	0	0	4	5	2	0	0	0	11
1919	0	0	0	0	0	0	4	5	4	0	0	0	13
1920	0	0	0	0	0	0	5	9	8	0	0	0	22
1921	0	0	0	0	0	0	5	7	6	0	0	0	18
1922	0	0	0	0	0	0	3	4	10	0	0	0	17
1923	0	0	0	0	0	0	4	9	9	0	0	0	22
1924	0	0	0	0	0	0	4	10	8	0	0	0	22
1925	0	0	0	0	0	0	4	5	3	0	0	0	12
1926	0	0	0	0	0	0	5	2	5	0	0	0	12
1927	0	0	0	0	0	0	4	8	9	0	0	0	21
TOTAL	0	0	0	0	0	0	156	203	214	0	0	0	573

TABLE 138 - NUMBER OF DEFICITS BELOW ELEVATION 99.2 FEET MSL, MINIMUM RELEASE = NET INFLOW MARCH - JUNE, AVERAGE MONTHLY FLOW REST OF YEAR BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1891	0	0	0	0	0	0	0	0	0	0	0	0	0
1892	0	0	0	0	0	0	0	0	0	0	0	0	0
1893	0	0	0	0	0	0	0	0	0	0	0	0	0
1894	0	0	0	0	0	0	0	0	0	0	0	0	0
1895	0	0	0	0	0	0	0	0	0	0	0	0	0
1896	0	0	0	0	0	0	0	0	0	0	0	0	0
1897	0	0	0	0	0	0	0	0	0	0	0	0	0
1898	0	0	0	0	0	0	0	0	0	0	0	0	0
1899	0	0	0	0	0	0	0	0	0	0	0	0	0
1900	0	0	0	0	0	0	0	0	0	0	0	0	0
1901	0	0	0	0	0	0	0	0	0	0	0	0	0
1902	0	0	0	0	0	0	0	0	0	0	0	0	0
1903	0	0	0	0	0	0	0	0	0	0	0	0	0
1904	0	0	0	0	0	0	0	0	0	0	0	0	0
1905	0	0	0	0	0	0	0	0	0	0	0	0	0
1906	0	0	0	0	0	0	0	0	0	1	3	0	4
1907	0	0	0	0	0	0	0	0	0	0	0	0	0
1908	0	0	0	0	0	0	0	0	0	0	0	0	0
1909	0	0	0	0	0	0	0	0	0	0	0	0	0
1910	0	0	0	0	0	0	0	0	0	0	0	0	0
1911	0	0	0	0	0	0	0	0	0	0	0	0	0
1912	0	0	0	0	0	0	0	0	0	0	0	0	0
1913	0	0	0	0	0	0	0	0	0	0	0	0	0
1914	0	0	0	0	0	0	0	0	0	0	0	0	0
1915	0	0	0	0	0	0	0	0	0	1	0	1	2
1916	0	0	0	0	0	0	0	0	0	0	0	0	0
1917	0	0	0	0	0	0	0	0	0	0	0	0	0
1918	0	0	0	0	0	0	0	0	0	0	0	0	0
1919	0	0	0	0	0	0	0	0	0	0	0	0	0
1920	0	0	0	0	0	0	0	0	0	0	0	0	0
1921	0	0	0	0	0	0	0	0	0	0	0	0	0
1922	0	0	0	0	0	0	0	0	0	0	0	0	0
1923	0	0	0	0	0	0	0	0	0	0	0	0	0
1924	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0	0	0	0	0	0	0
1926	0	0	0	0	0	0	0	0	0	0	0	0	0
1927	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	0	0	2	3	1	6

TABLE 139 - MINIMUM POOL ELEVATIONS
MINIMUM RELEASE = NET INFLOW MARCH - JUNE,
RELEASE = AVERAGE MONTHLY FLOW REST OF YEAR
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1891	106.17	107.23	107.23	107.23	107.23	107.23	106.17	104.99	102.66	103.60	106.09	106.17
1892	106.17	106.17	107.23	107.23	107.23	107.23	105.80	104.27	101.27	101.27	100.60	100.60
1893	101.91	100.04	107.23	107.23	107.23	107.23	106.17	106.17	105.22	104.21	104.11	102.62
1894	106.06	101.99	107.23	107.23	107.23	107.23	106.17	106.17	102.37	101.82	103.50	102.03
1895	102.03	106.17	107.23	107.23	107.23	107.23	105.23	105.23	105.23	105.23	105.23	105.23
1896	106.13	103.50	107.23	107.23	107.23	107.23	105.39	102.98	102.98	99.29	104.60	104.77
1897	106.17	103.30	107.23	107.23	107.23	107.23	105.27	105.13	105.13	104.75	102.18	100.17
1898	105.08	106.17	107.23	107.23	107.23	107.23	106.17	103.55	103.33	103.33	104.[illegible]	103.17
1899	102.68	102.68	107.23	107.23	107.23	107.23	106.17	104.70	103.26	103.26	105.73	104.34
1900	104.34	105.84	107.23	107.23	107.23	107.23	106.17	106.17	106.17	106.17	106.17	105.34
1901	105.34	105.34	107.23	107.23	107.23	107.23	105.69	105.14	106.17	105.57	104.26	102.29
1902	103.14	103.81	107.23	107.23	107.23	107.23	106.76	105.32	105.32	102.84	104.04	104.04
1903	100.84	105.61	107.23	107.23	107.23	107.23	104.69	104.21	104.80	104.80	105.52	104.09
1904	104.09	106.07	107.23	107.23	107.23	107.23	104.17	104.17	105.29	101.83	101.83	101.83
1905	106.17	106.17	107.23	107.23	107.23	107.23	104.57	104.77	104.06	105.16	105.13	105.82
1906	106.17	106.12	107.23	107.23	107.23	107.23	106.17	102.58	101.36	98.78	98.75	100.44
1907	106.38	106.17	107.23	107.23	107.23	107.23	106.17	106.17	104.75	104.70	106.17	104.04
1908	106.17	106.17	107.23	107.23	107.23	107.23	106.17	106.17	106.17	106.17	106.17	106.17
1909	106.17	102.91	107.23	107.23	107.23	107.23	106.17	106.17	106.17	106.17	106.17	106.17
1910	104.57	104.57	107.23	107.23	107.23	107.23	106.17	106.17	106.17	106.17	106.17	106.17
1911	105.86	102.19	107.23	107.23	107.23	107.23	106.17	106.17	106.49	105.68	103.38	103.35
1912	105.86	105.86	107.23	107.23	107.23	107.23	106.17	106.01	106.01	105.94	103.65	101.99
1913	104.47	104.17	107.23	107.23	107.23	107.23	106.17	106.17	106.17	106.17	104.50	105.59
1914	106.17	106.17	107.23	107.23	107.23	107.23	106.17	103.21	103.21	103.21	103.21	103.21
1915	102.79	102.95	107.23	107.23	107.23	107.23	104.83	100.77	99.31	99.04	102.16	99.09
1916	100.21	106.17	107.23	107.23	107.23	107.23	104.44	106.00	106.00	105.04	105.04	105.04
1917	103.81	103.81	107.23	107.23	107.23	107.23	104.70	103.03	105.27	102.94	102.50	102.50
1918	102.50	102.50	107.23	107.23	107.23	107.23	106.17	106.17	106.17	102.81	103.99	102.62
1919	105.24	105.25	107.23	107.23	107.23	107.23	105.34	105.86	105.88	105.74	105.95	102.34
1920	102.34	102.34	102.88	107.23	107.23	107.23	104.19	102.22	101.33	99.30	99.30	106.01
1921	106.17	106.17	107.23	107.23	107.23	107.23	106.17	104.85	104.85	106.17	106.17	102.11
1922	102.11	102.11	107.23	107.23	107.23	107.23	105.69	105.69	103.84	103.84	103.84	103.84
1923	104.89	104.89	107.23	107.23	107.23	107.23	106.17	104.47	104.47	104.47	104.44	104.44
1924	105.40	105.58	107.23	107.23	107.23	107.23	104.60	104.60	104.87	103.20	103.20	103.20
1925	103.20	103.20	107.23	107.23	107.23	107.23	106.17	106.07	106.07	105.53	103.97	106.17
1926	106.17	106.17	107.23	107.23	107.23	107.23	106.17	106.17	104.97	104.16	105.71	105.32
1927	105.32	100.52	107.23	107.23	107.23	107.23	106.17	105.15	104.87	104.87	106.18	106.17

TABLE 140

MONTHS WITH NO PEAKING
POWER GENERATION
SCHEME 4c

1892	October
1893	August
1895	August, September, October and November
1897	October
1899	July, September and October
1900	July, August, September and October
1901	January and February
1904	November
1905	February
1907	February and August
1908	August through December
1909	August through December
1910	July through December
1911	July
1912	July
1913	February, August and September
1914	September, October, November and December
1916	November and December
1917	February and December
1918	January and August
1919	February and September
1920	January and February
1921	January, July and October
1922	January, September, October, November and December
1923	February, August, September and November
1924	November and December

5. Discussion of Results

The results of these simulations are summarized in Table 141. The power generation is expressed in terms of the product of discharge and effective net head. In order to obtain power generation in horsepower, it is necessary to multiply the values given by $\eta\gamma/550$ where η is the efficiency, and γ is the unit weight of water. If the turbines are assumed 90% efficient, the multiplicative factor is 0.102. The power generation in horsepower can be converted to kilowatts by multiplying by 0.745.

In Table 141, column 7 represents the peaking power available during the 14-year period under each scheme expressed as a ratio to the total power generated. The computation is made for inflows less than 86000 cfs. Under conditions with no minimum release all generation at inflows less than 86000 cfs would be peaking power. The amount of peaking power lost due to a particular release scheme is given by one minus the value in column 7. Again, the requirement that the release be equal to the (net) inflow at all times results in loss of all peaking power generation. The run-of-river release for four months with a minimum release of average monthly flows the remaining months, results in loss of 88% of the peaking generation. The run-of-river release for four months followed by a release equal to the minimum average monthly flow results in loss of about 67% of the peaking generation. Finally, if the minimum release is set equal to the minimum average monthly flow in all months, about 41% of the peaking power generation is lost.

Column 8 of Table 141 shows the change in total power generation as a ratio to the total power generated for the base case. The total power generated actually increases for most of the release schemes. However, the amount of increase is very small. The largest increase is about 1.5% for the scheme with run-of-river release at all times.

The period 1891-1927 shows similar results in comparison with the period 1961-1974.

H. Simulation of Conowingo Release Requirements Based on Fishery Needs

1. Proposal by Combined Fishery Agencies

The Susquehanna River Basin Commission staff, U.S. Fish and Wildlife Service, Maryland Fisheries Administration, Pennsylvania Fish Commission, and U.S. Geological Survey made field measurements and hydraulic and biologic analyses in an attempt to determine the effect of releases on the fishery downstream from Conowingo. The study is described by Jackson and Lazorchick (6).

TABLE 141

SUMMARY OF SIMULATION RESULTS
NATURAL FLOW CONDITIONS

SCHEME (1)	NO. OF OCCURRENCES POOL ELEVATION LESS THAN 107.2 (2)	99.2 (3)	MINIMUM POOL FT. MSL (4)	TOTAL POWER BILLION CFS FT. (5)	PEAK POWER BILLION CFS FT. (6)	(6)÷(5) (7)	TOTAL POWER AS RATIO TO BASE TOTAL (5)÷BASE (8)
3. Period 1961-1974							
Base(a.)	362	56	96.10	13.444	13.444	1.000	1.000
b.	49	0	106.17	13.654	---	0.000	1.0156
c.	215	23	97.13	13.537	1.646	0.1216	1.0069
d.	168	0	100.57	13.550	4.512	0.3330	1.0079
e.	424	455	94.76	13.392	7.916	0.5911	0.9961
4. Period 1891-1927							
Base(a.)	703	3	98.89	36.111	36.111	1.000	1.000
b.	53	0	106.17	36.569	36.569	1.000	1.013
c.	573	6	98.75	36.320	5.159	0.1420	1.006

As a result of that study, the fishery agencies recommended certain flow release schemes that would be most beneficial for the fishery indicator species existing and/or desirable downstream from Conowingo. In accordance with those recommendations the following conditions were simulated.

a. Base case - no continuous release. The Chester, Peach Bottom and evaporative withdrawals, plus a Baltimore withdrawal of 388 cfs (250 mgd) were used.

b. Minimum releases as follows:

	CASE 1	CASE 2	CASE 3
January	17600	12000	17600
February	17600	12000	17600
March	15000	12000	15000
April	15000	12000	65000
May	15000	12000	39500
June	15000	12000	15000
July	17600	12000	17600
August	12000	5000	12000
September	12000	5000	12000
October	12000	5000	12000
November	17600	12000	17600
December	17600	12000	17600

Withdrawals same as for base case.

In all cases if the required release was greater than the net inflow the release was set equal to the net inflow, which is defined as the observed inflow minus the withdrawals for Chester, Baltimore and Peach Bottom.

The program described in Section IV.G. was used for these simulations.

The deficits below elevations 107.2 feet msl, and 99.2 feet msl for the base case are shown in Tables 142 and 143, respectively. The minimum pool elevations are summarized in Table 144.

The deficits below elevations 107.2 feet msl and 99.2 feet msl for release scheme 1 are shown in Tables 145 and 146, respectively. The minimum pool elevations are summarized in Table 147.

The deficits below elevations 107.2 feet msl and 99.2 feet msl for release scheme 2 are shown in Tables 148 and 149, respectively. The minimum pool elevations are summarized in Table 150.

TABLE 142 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL,
NO MINIMUM RELEASE
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1961	0	0	0	0	1	0	0	1	0	0	0	0	2
1962	0	0	0	0	1	7	9	8	10	0	0	0	35
1963	0	0	0	0	0	0	2	4	9	0	0	0	15
1964	0	0	0	0	0	6	8	10	8	0	0	0	32
1965	0	0	0	0	10	8	9	9	8	0	0	0	44
1966	0	0	0	0	4	2	10	8	8	0	0	0	32
1967	0	0	0	0	2	0	7	8	9	0	0	0	26
1968	0	0	0	0	2	5	8	9	7	0	0	0	31
1969	0	0	0	0	5	4	8	7	8	0	0	0	32
1970	0	0	0	0	1	2	3	5	2	0	0	0	13
1971	0	0	0	0	9	8	9	9	8	0	0	0	43
1972	0	0	0	0	0	3	0	0	7	0	0	0	10
1973	0	0	0	0	7	1	5	6	7	0	0	0	26
1974	0	0	0	0	2	2	0	8	9	0	0	0	21
TOTAL	0	0	0	0	44	48	78	92	100	0	0	0	362

TABLE 143 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL,
NO MINIMUM RELEASE
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	2	6	16	24
1966	24	8	0	0	0	0	0	0	0	0	0	0	32
1967	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	24	8	0	0	0	0	0	0	0	2	6	16	56

TABLE 144 -- MINIMUM POOL ELEVATIONS
NO MINIMUM RELEASE
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1961	106.15	105.46	107.23	107.23	106.67	105.50	105.69	105.85	105.45	106.72	105.88	103.81
1962	103.97	105.04	106.09	107.23	105.12	105.70	105.09	105.03	104.38	101.85	103.61	103.74
1963	105.57	105.29	106.27	106.44	105.83	105.36	106.61	106.26	105.65	105.31	105.30	105.05
1964	103.39	105.28	105.68	107.23	105.49	104.15	104.15	103.86	103.08	103.60	103.25	101.93
1965	101.45	106.07	104.91	103.05	102.14	102.18	102.20	101.11	100.31	98.67	95.98	96.34
1966	96.10	98.19	107.23	105.90	106.09	104.96	105.08	104.48	104.39	103.73	101.99	102.08
1967	101.38	100.85	100.75	106.99	106.37	105.56	102.43	101.91	101.59	100.69	99.22	106.60
1968	104.97	104.32	103.26	105.50	105.17	105.04	103.38	104.76	104.63	102.91	102.70	105.08
1969	105.16	105.17	105.24	106.36	104.55	104.17	103.20	103.63	104.94	104.79	104.25	104.42
1970	103.67	106.74	106.10	107.23	106.57	105.32	104.91	105.47	105.65	104.00	102.73	107.10
1971	105.59	105.58	107.23	105.73	103.48	102.23	102.57	103.13	100.98	99.97	99.61	101.08
1972	106.03	104.23	107.15	107.23	107.23	105.96	106.45	105.27	105.78	105.62	104.29	107.23
1973	106.05	106.22	105.67	105.99	105.43	106.12	104.07	102.64	104.37	104.48	103.20	101.66
1974	107.12	105.69	106.57	107.23	106.13	104.92	105.73	104.50	102.32	102.20	102.30	102.61

TABLE 145 - NUMBER OF DEFICITS BELOW ELEVATION 107.2 FEET MSL,
MINIMUM RELEASE = SCHEME 1 PROPOSED BY FISHERY INTERESTS,
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1961	0	0	0	0	1	6	10	8	9	0	0	0	34
1962	0	0	0	0	7	9	9	8	10	0	0	0	43
1963	0	0	0	0	3	2	4	4	5	0	0	0	18
1964	0	0	0	0	2	4	4	5	4	0	0	0	19
1965	0	0	0	0	10	8	9	9	8	0	0	0	44
1966	0	0	0	0	5	8	10	8	8	0	0	0	39
1967	0	0	0	0	2	8	10	8	9	0	0	0	37
1968	0	0	0	0	1	3	5	4	6	0	0	0	19
1969	0	0	0	0	3	7	8	10	8	0	0	0	36
1970	0	0	0	0	2	6	5	4	4	0	0	0	21
1971	0	0	0	0	8	8	9	9	8	0	0	0	42
1972	0	0	0	0	0	2	1	8	9	0	0	0	20
1973	0	0	0	0	7	1	3	4	6	0	0	0	21
1974	0	0	0	0	0	8	7	9	9	0	0	0	33
TOTAL	0	0	0	0	51	80	94	98	103	0	0	0	426

TABLE 146 - NUMBER OF DEFICITS BELOW ELEVATION 99.2 FEET MSL,
MINIMUM RELEASE = SCHEME 1 PROPOSED BY FISHERY INTERESTS,
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	3	5	0	0	0	0	0	0	0	0	0	0	8
1966	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	2	0	0	0	2	4
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	5	5
1974	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	3	5	0	0	0	0	0	2	0	0	0	7	17

TABLE 147 - MINIMUM POOL ELEVATIONS
MINIMUM RELEASE = SCHEME 1 PROPOSED BY FISHERY INTERESTS,
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1961	106.17	105.99	107.23	107.23	105.83	102.44	101.44	103.09	101.92	101.92	101.92	100.51
1962	101.51	102.13	105.09	107.23	104.53	104.53	104.53	104.53	104.53	101.71	101.71	104.37
1963	101.46	100.80	100.80	104.16	103.92	106.17	106.17	106.17	106.17	106.17	106.17	100.80
1964	102.75	104.32	104.32	106.88	105.51	105.49	105.49	105.49	105.49	105.49	105.49	105.49
1965	98.35	97.03	105.15	103.23	102.14	103.64	103.64	103.64	103.64	103.05	103.05	102.63
1966	102.67	102.94	107.20	104.05	104.00	99.68	99.68	99.68	99.68	99.68	99.68	101.04
1967	102.71	104.23	104.09	106.00	105.10	104.55	103.83	101.67	100.48	100.09	99.89	104.88
1968	104.59	104.45	106.17	106.28	107.01	104.16	105.72	105.72	104.84	105.11	103.59	104.98
1969	106.00	105.39	105.54	105.40	105.25	104.73	102.06	101.25	101.84	101.84	100.61	102.57
1970	106.10	106.17	104.85	107.23	105.56	103.34	104.06	105.86	105.88	105.88	104.78	105.24
1971	101.58	101.58	107.23	104.41	103.05	101.45	101.62	98.68	99.43	99.75	100.12	98.42
1972	104.49	104.05	106.11	106.87	106.84	105.11	105.76	104.53	104.53	104.53	104.53	107.04
1973	102.03	103.62	105.69	105.22	104.56	105.45	105.97	106.17	105.45	103.18	99.81	98.14
1974	105.34	105.37	105.93	107.01	105.67	103.40	103.17	104.63	101.63	99.99	99.99	101.50

TABLE 148 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FEET MSL,
MINIMUM RELEASE = SCHEME 2 PROPOSED BY FISHERY INTERESTS,
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1961	0	0	0	0	1	8	10	2	8	0	0	0	29
1962	0	0	0	0	4	4	5	4	10	0	0	0	27
1963	0	0	0	0	2	2	4	4	5	0	0	0	17
1964	0	0	0	0	4	8	8	10	8	0	0	0	38
1965	0	0	0	0	10	8	9	9	8	0	0	0	44
1966	0	0	0	0	5	8	10	8	8	0	0	0	39
1967	0	0	0	0	2	3	9	8	9	0	0	0	31
1968	0	0	0	0	0	5	4	4	5	0	0	0	18
1969	0	0	0	0	4	9	8	10	8	0	0	0	39
1970	0	0	0	0	1	5	1	5	3	0	0	0	15
1971	0	0	0	0	8	8	9	9	8	0	0	0	42
1972	0	0	0	0	0	4	2	8	9	0	0	0	23
1973	0	0	0	0	7	1	3	4	2	0	0	0	17
1974	0	0	0	0	0	8	8	8	9	0	0	0	33
TOTAL	0	0	0	0	48	81	90	93	100	0	0	0	412

TABLE 149 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 MSL,
MINIMUM RELEASE = SCHEME 2 PROPOSED BY FISHERY INTERESTS,
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	2	0	0	0	0	0	0	0	0	0	0	2
1966	0	0	0	0	0	0	0	0	0	8	13	7	28
1967	5	0	0	0	0	0	0	0	0	0	0	0	5
1968	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	1	0	0	1
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	1	1
1974	0	0	0	0	0	0	0	0	0	0	8	0	8
TOTAL	5	2	0	0	0	0	0	0	0	9	21	8	45

TABLE 150 -- MINIMUM POOL ELEVATIONS
MINIMUM RELEASE = SCHEME 2 PROPOSED BY FISHERY INTERESTS,
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1961	105.95	105.95	107.23	107.23	106.00	102.84	103.11	106.02	105.23	105.20	104.18	101.66
1962	102.20	104.75	105.28	107.23	105.09	105.25	105.25	105.25	104.05	102.25	101.54	103.35
1963	102.05	100.93	100.93	104.98	104.56	106.17	106.17	106.17	106.17	106.17	106.17	102.41
1964	104.13	105.49	104.72	107.04	105.07	103.39	103.39	103.39	104.28	104.28	104.28	104.28
1965	99.65	98.20	103.95	102.08	101.27	101.07	101.07	100.66	100.66	100.56	100.56	99.34
1966	99.51	99.51	107.23	105.33	104.49	99.21	99.21	99.21	99.25	98.18	96.75	98.06
1967	97.87	99.45	100.79	106.22	105.42	105.43	104.68	101.18	100.79	101.42	99.34	105.80
1968	104.63	104.17	104.66	106.49	106.94	104.54	104.70	105.92	104.73	104.54	101.87	105.08
1969	104.90	103.75	102.32	105.61	104.76	103.12	100.87	100.59	101.64	101.47	101.47	102.91
1970	103.74	105.78	104.63	107.23	105.42	104.15	105.77	105.82	106.55	105.05	102.85	105.85
1971	104.38	104.34	107.23	104.77	103.14	101.79	102.02	101.17	100.65	99.05	99.75	99.43
1972	104.87	104.49	107.23	107.05	106.51	104.32	105.93	104.63	103.32	103.05	103.15	107.23
1973	104.23	105.76	105.53	105.44	104.75	105.48	105.31	104.98	105.74	104.75	101.05	99.04
1974	105.93	105.13	106.38	107.15	105.14	102.49	102.50	103.58	100.36	99.54	97.50	99.84

The deficits below elevations 107.2 feet msl and 99.2 feet msl for release scheme 3 are summarized in Tables 151 and 152, respectively. The minimum pool elevations are summarized in Table 153.

The results of the simulations are summarized in Table 154. Note that power generation is expressed in terms of the product of discharge and effective net head. Conversion of these values to horsepower and to kilowatts has been discussed in Section IV.G.5.

In Table 154, column 7 shows the amount of peaking power available during the 14-year period under each schema, expressed as a ratio to the total power generated. The computation is made for inflows less than 86000 cfs. Under conditions with no required release the present operation is such that all generation at inflows less than 86000 cfs would be peaking power. Therefore, the amount of peaking power lost due to the release scheme is given by one minus the value in column 7.

Case 3, which is the most severe case, results in a loss of 58% of the peaking power that could have been generated and also results in considerably more occurrences of pool elevations less than 99.2 feet msl. Case 2, which is the least severe case, results in a loss of 32% of the peaking power, and Case 1 results in a loss of 43% of the peaking power. Notice that Case 2 and Case 1 result in fewer occurrences of pool elevations less than 99.2 feet msl, even in comparison with the base case.

2. Proposal by Maryland Fisheries Administration

Following their analysis of the results of the instream flow needs study, Maryland Fisheries Administration (MFA) requested a simulation of the following release scheme:

Period	Continuous Release	Exception
January-May	15000 cfs	
June 1-7	12700 cfs	
June 8-14	10400 cfs	When 80% of the net river flow is equal to or less than the required release the release is set equal to 80% of the net inflow.
June 15-21	8100 cfs	
June 22-28	5800 cfs	
June 29-30	3500 cfs	
July-November	3500 cfs	
December 1-7	5800 cfs	
December 8-14	8100 cfs	
December 15-21	10400 cfs	
December 22-28	12700 cfs	
December 29-31	15000 cfs	

TABLE 151 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FEET MSL,
MINIMUM RELEASE = SCHEME 3 PROPOSED BY FISHERY INTERESTS,
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1961	0	0	0	0	3	4	10	8	9	0	0	0	34
1962	0	0	0	0	3	4	5	4	5	0	0	0	21
1963	0	0	0	0	5	10	8	9	9	0	0	0	41
1964	0	0	0	0	3	4	4	5	4	0	0	0	20
1965	0	0	0	0	8	8	9	9	8	0	0	0	42
1966	0	0	0	0	2	8	10	8	8	0	0	0	36
1967	0	0	0	0	3	8	10	8	9	0	0	0	38
1968	0	0	0	0	5	3	5	4	6	0	0	0	23
1969	0	0	0	0	4	6	8	10	8	0	0	0	36
1970	0	0	0	0	8	8	8	10	8	0	0	0	42
1971	0	0	0	0	10	8	9	9	8	0	0	0	44
1972	0	0	0	0	2	4	1	8	9	0	0	0	24
1973	0	0	0	0	3	1	3	4	6	0	0	0	17
1974	0	0	0	0	3	6	6	3	9	0	0	0	27
TOTAL	0	0	0	0	62	82	96	99	106	0	0	0	445

TABLE 152 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FEET MSL,
MINIMUM RELEASE = SCHEME 3 PROPOSED BY FISHERY INTERESTS,
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	3	4	0	0	0	0	0	0	0	0	0	0	7
1966	0	0	0	0	0	2	5	4	4	5	4	0	24
1967	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	1	0	0	0	0	0	0	1
1971	0	0	0	9	21	30	31	31	30	31	30	8	221
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	5	5
1974	0	0	.0	0	0	0	0	0	0	0	0	0	0
TOTAL	3	4	0	9	21	33	36	35	34	36	34	13	258

TABLE 153 -- MINIMUM POOL ELEVATIONS
MINIMUM RELEASE = SCHEME 3 PROPOSED BY FISHERY INTERESTS,
BALTIMORE WITHDRAWAL 250 MGD (388 CFS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1961	106.17	105.99	107.23	106.17	105.51	103.38	102.38	104.03	102.85	102.85	102.85	101.44
1962	102.45	103.07	105.09	105.83	106.17	106.17	106.17	106.17	106.17	101.83	101.83	104.37
1963	101.46	100.80	100.80	106.17	101.66	104.67	104.67	104.67	104.67	104.67	104.67	99.22
1964	101.26	104.32	104.32	105.92	106.17	105.76	105.76	105.76	105.76	105.76	105.76	105.76
1965	98.65	97.34	105.15	103.78	104.34	103.98	103.98	103.98	103.98	103.39	103.39	102.97
1966	103.01	103.28	107.20	104.32	104.19	98.87	98.87	98.87	98.87	98.87	98.87	100.32
1967	101.99	104.23	104.09	106.17	103.89	104.46	103.75	101.58	100.40	100.00	99.80	104.88
1968	104.59	104.45	106.17	106.17	104.83	104.16	105.72	105.72	104.84	105.11	103.59	104.98
1969	106.00	105.39	105.54	104.92	104.62	104.73	102.06	101.25	101.84	101.84	100.61	102.57
1970	106.10	106.17	104.85	106.74	100.92	98.64	99.45	101.93	101.96	101.96	104.45	105.24
1971	101.58	101.58	107.23	95.90	91.27	89.72	89.92	86.62	87.41	87.74	98.15	86.35
1972	104.49	104.05	106.11	104.08	103.27	104.47	105.76	104.53	104.53	104.53	104.53	107.04
1973	102.03	103.62	105.69	105.98	104.65	105.45	105.97	106.17	105.45	103.18	99.81	98.14
1974	105.34	105.37	105.93	106.17	106.17	104.57	104.34	105.80	102.80	101.17	101.17	102.67

TABLE 154

SUMMARY OF SIMULATIONS USING MINIMUM RELEASES RECOMMENDED BY FISHERY INTERESTS

SCHEME (1)	NO.OF DAYS LESS THAN 107.2 (2)	NO.OF DAYS LESS THAN 99.2 (3)	MIN. POOL ELEV. (4)	TOTAL POWER AVAILABLE BILLION CFS FT. (5)	TOTAL PEAK POWER AVAIL. BILLION CFS FT. (6)	(6) ÷ (5) (7)	TOTAL POWER AS RATIO TO BASE TOTAL (5) ÷ BASE (8)
Base	362	56	96.10	13.444	13.444	1.00	---
1	426	17	97.03	13.436	7.712	0.574	0.999
2	412	45	96.75	13.411	9.100	0.679	0.997
3	446	258	86.35	13.382	5.566	0.416	0.995

This scheme was simulated using the same program described in Section IV.G. The release algorithm was modified as follows:

a. Compute the net inflow by subtracting the withdrawals from the Marietta observed daily flow.

b. Determine whether 80% of net inflow is less than value shown in the above table for that date. If not, set the release to the value shown in the above table and modify power generation operating curves, as discussed in Section IV.G.

c. If 80% of net inflow is less than value shown in the above table for that date, set release at 80% of net inflow and modify operating curve to permit peaking power generation with remaining flow, as described in Section IV.G.

The peaking power generation lost was defined using the base case and subtracting the withdrawals as discussed in Section IV.G. The summary of pool elevations for the base case is shown in Table 144.

For the scheme proposed by MFA, the deficits below elevations 107.2 feet msl and 99.2 feet msl are shown in Tables 155 and 156, respectively. The minimum pool elevations are shown in Table 157. The results of the simulation are summarized in Table 161 which corresponds to Table 141.

Note that in comparison with the base case, this scheme results in increasing the number of days on which the pool elevation is below 107.2 feet msl and 99.2 feet msl. The minimum pool elevation is also somewhat lower for this scheme. The total power available is about the same, and the peaking power lost is about 30% of the peaking power available for the base case.

For the sake of brevity, designate the scheme discussed in this section as the present scheme, and scheme 2 discussed in Section IV.H.1. as the previous scheme. Then the present scheme in comparison to the previous scheme results in fewer deficits below elevation 107.2 feet msl but more deficits below 99.2 feet msl. As in the previous simulations deficits below elevation 107.2 feet msl are computed only on weekends but deficits below 99.2 feet msl are computed year round. The minimum pool elevation for the present scheme is almost 1.0 feet lower than for the previous scheme. However, there is about 4% more peaking power available under the present scheme in comparison with the previous scheme.

The apparent inconsistency in the relationship between deficits below elevations 107.2 and 99.2 when comparing this

TABLE 155 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL
PROPOSAL BY MARYLAND FISHERIES ADMINISTRATION

YEAR	JAN	FEB	MAR	APR.	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1961	0	0	0	0	1	2	1	2	7	0	0	0	13
1962	0	0	0	0	7	8	5	4	10	0	0	0	34
1963	0	0	0	0	3	0	2	4	5	0	0	0	14
1964	0	0	0	0	2	7	8	10	8	0	0	0	35
1965	0	0	0	0	10	8	9	9	8	0	0	0	44
1966	0	0	0	0	5	8	10	8	8	0	0	0	39
1967	0	0	0	0	2	1	7	8	9	0	0	0	27
1968	0	0	0	0	1	5	8	9	9	0	0	0	32
1969	0	0	0	0	3	2	5	2	4	0	0	0	16
1970	0	0	0	0	2	7	8	9	8	0	0	0	34
1971	0	0	0	0	8	8	9	9	8	0	0	0	42
1972	0	0	0	0	0	3	0	5	9	0	0	0	17
1973	0	0	0	0	7	2	8	8	7	0	0	0	32
1974	0	0	0	0	0	3	0	5	8	0	0	0	16
TOTAL	0	0	0	0	51	64	80	92	108	0	0	0	395

TABLE 156 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL
PROPOSAL BY MARYLAND FISHERIES ADMINISTRATION

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	15	10	0	0	0	0	0	0	0	0	0	2	27
1966	0	0	0	0	0	2	9	9	6	15	24	21	86
1967	7	0	0	0	0	0	0	0	0	0	0	0	7
1968	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	1	1	2	7	18	4	33
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	22	10	0	0	0	2	10	10	8	22	42	27	153

TABLE 157 -- MINIMUM POOL ELEVATION
PROPOSAL BY MARYLAND FISHERIES ADMINISTRATION

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1961	106.47	106.30	107.23	107.23	105.83	104.39	106.41	105.74	105.43	105.07	103.80	101.54
1962	101.85	104.50	105.09	107.23	104.62	105.32	105.50	105.56	104.80	102.95	102.78	102.56
1963	99.75	99.34	99.24	104.16	103.92	105.62	106.74	106.09	106.01	106.05	105.72	105.67
1964	103.84	104.73	105.57	106.88	105.51	103.31	101.76	101.55	102.09	102.15	102.10	102.67
1965	96.51	94.93	105.15	103.23	102.14	102.92	102.77	101.94	101.65	101.51	99.24	98.58
1966	100.03	100.35	107.20	104.05	104.00	98.72	97.80	97.67	97.95	96.93	96.20	95.34
1967	97.84	100.54	99.64	106.00	105.10	105.09	103.13	101.06	100.68	100.98	99.33	105.85
1968	105.96	105.30	107.23	106.28	107.01	103.83	102.89	102.71	102.76	102.01	101.96	104.96
1969	104.82	104.80	103.84	105.40	105.25	105.00	103.99	104.87	105.58	105.62	105.21	104.55
1970	105.97	106.48	104.81	107.23	105.56	103.44	102.99	104.53	105.15	104.32	103.04	106.13
1971	103.68	104.81	107.23	104.41	103.05	100.36	99.09	99.16	97.94	96.76	96.96	97.99
1972	104.75	104.39	107.01	106.87	106.84	104.55	106.07	105.25	104.69	104.42	103.19	107.23
1973	103.16	104.64	105.47	105.22	104.56	105.36	103.63	102.34	104.40	103.80	102.01	100.31
1974	105.61	105.52	105.93	107.01	105.67	104.43	106.01	105.85	102.41	102.20	101.95	102.37

scheme to the previous scheme appears to be due to a combination of the magnitude of the minimum release and the procedure used to adjust the operating curves. The following table is a comparison of the two release schemes:

	Minimum Release CFS	
Month	Present Scheme	Previous Scheme
January	15000	12000
February	15000	12000
March	15000	12000
April	15000	12000
May	15000	12000
June	Variable	12000
July	3500	12000
August	3500	5000
September	3500	5000
October	3500	5000
November	3500	12000
December	Variable	12000

The scheme used for modifying the operating curves as discussed in Section IV.G. results in an increase in total water released depending on the ratio of inflow to release constraint when inflow is greater than the release. This is caused by the shape of the operating curves and the assumptions used in modifying the operation curves.

When comparing the two schemes, the present scheme will result in more deficiencies below 99.2 ft. msl in comparison with the previous scheme when two basic conditions exist (see Figure 33):

a. When a greater continuous release is required by the present scheme in comparison with the previous scheme, as generally indicated from January into early June, and the inflow exceeds a certain amount, the computed release will be greater for the present scheme than for the previous scheme;

b. When a lesser continuous release is required by the present scheme in comparison with the previous scheme, as generally indicated from June into December, and the net inflow is less than the continuous release for the previous scheme but greater than the continuous release for the present scheme, the computed release for the present scheme is again greater than that computed for the previous scheme.

Thus it seems reasonable that the pool will be drawn down below elevation 99.2 ft. msl more frequently for the present scheme.

However, there is no comparable increase in the number of deficits below 107.2 ft. msl. The deficits below 107.2 feet msl are computed only on weekends during the period May 1st

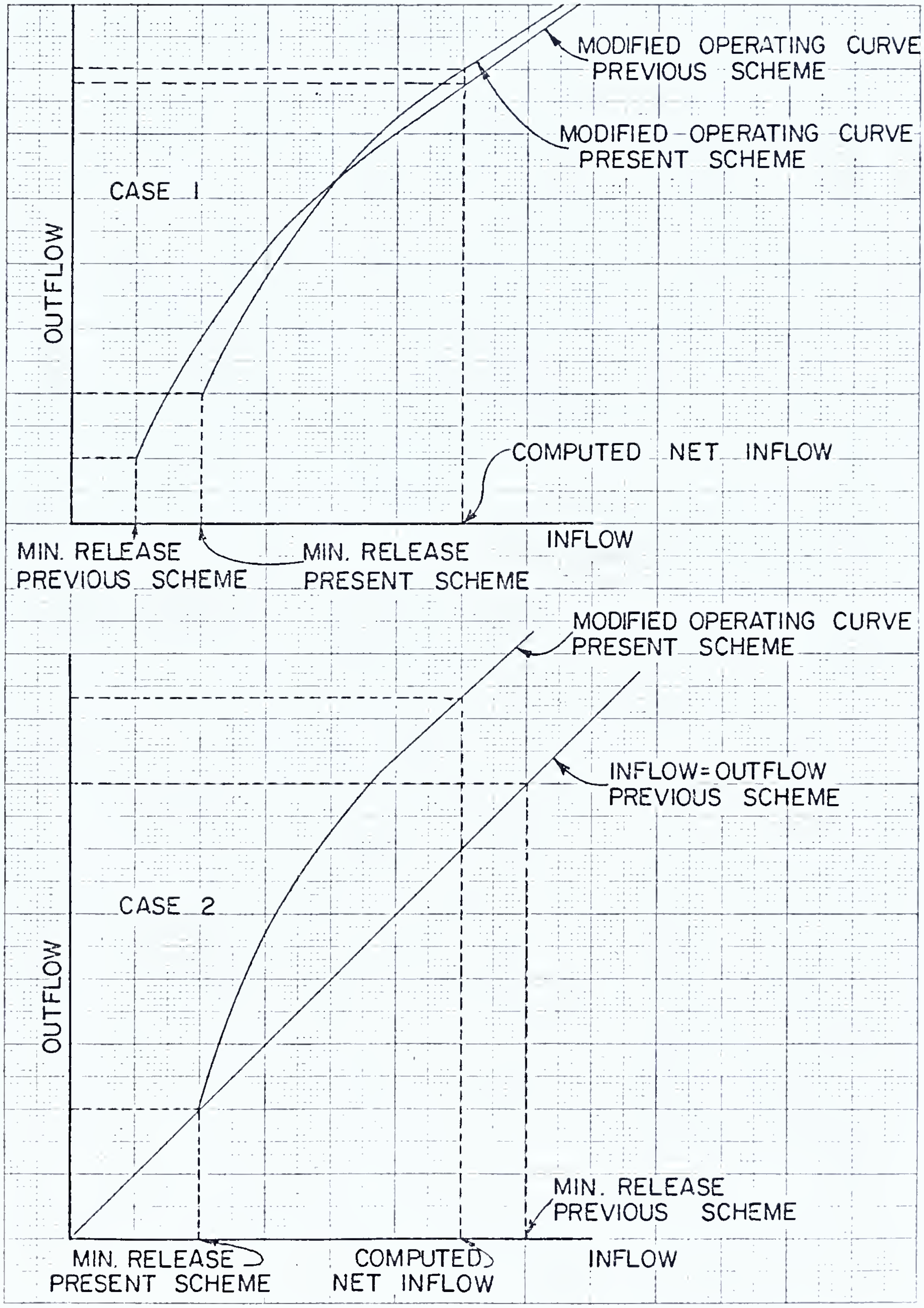

FIGURE 33
EFFECT OF DIFFERENT MINIMUM RELEASES
ON OPERATING CURVES

through September 30th. Comparison of Table 149 with Table 156 shows that there are 47 more occurrences of deficits below 99.2 ft. msl occurring during the months of January through April and October through December for the present scheme. In contrast there are only 26 more occurrences of deficits below 99.2 during the months of May through September for the present scheme. Also the increased deficits below 99.2 ft. msl occur in years when the minimum pool elevation is well below 107.2 ft. msl for both schemes as shown in Tables 150 and 157. Thus about 65% of the increase in deficits below elevation 99.2 ft. msl occurs during periods when deficits below 107.2 ft. msl are not computed, and the remainder of the increased deficits below 99.2 ft. msl occur when the pool elevation is below 107.2 ft. msl for both schemes

3. Maryland Proposal as Modified by Other Fishery Agencies

Pennsylvania Fish Commission and U.S. Fish and Wildlife Service disagreed with the proposal by Maryland outlined in the previous subsection. The minimum flow of 3500 cfs is deemed inadequate during the period June 29th through November 30th. Those agencies proposed that the minimum release during that period should be 5000 cfs. The reasons for the difference in the recommendation is discussed by Jackson and Lazorchick (6).

As a result of that revision of the recommendation the following scheme was developed and simulated.

Period	Continuous Release	Exception
January - May	15,000 cfs	
June 1-7	12,700 cfs	
June 8-14	10,400 cfs	When 80% of the net river flow is equal to or less than the required release the release is set equal to 80% of the net river flow.
June 15-21	8,100 cfs	
June 22-28	5,800 cfs	
June 29-30	5,000 cfs	
July - November	5,000 cfs	
December 1-7	5,800 cfs	
December 8-14	8,100 cfs	
December 15-21	10,400 cfs	
December 22-28	12,700 cfs	
December 29-30	15,000 cfs	

This release scheme was simulated using the program described in Section IV.G. and modified as described in Section IV. H.2. The base case and the withdrawals are the same as described in Section IV.G.

The deficits below elevation 107.2 ft. msl and 99.2 ft. msl are shown in Tables 158 and 159. The minimum pool eleva-

TABLE 158 -- NUMBER OF DEFICITS BELOW ELEVATION 107.2 FT. MSL, MODIFIED MARYLAND RELEASE SCHEME

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1961	0	0	0	0	1	2	4	2	8	0	0	0	17
1962	0	0	0	0	7	9	9	8	10	0	0	0	43
1963	0	0	0	0	3	0	3	4	5	0	0	0	15
1964	0	0	0	0	2	7	8	10	8	0	0	0	35
1965	0	0	0	0	10	8	9	9	8	0	0	0	44
1966	0	0	0	0	5	8	10	8	8	0	0	0	39
1967	0	0	0	0	2	1	9	8	9	0	0	0	29
1968	0	0	0	0	1	5	8	9	9	0	0	0	32
1969	0	0	0	0	3	2	6	6	5	0	0	0	22
1970	0	0	0	0	2	7	6	8	7	0	0	0	30
1971	0	0	0	0	8	8	9	9	8	0	0	0	42
1972	0	0	0	0	0	3	0	2	9	0	0	0	14
1973	0	0	0	0	7	2	8	8	8	0	0	0	33
1974	0	0	0	0	0	4	0	3	8	0	0	0	15
TOTAL	0	0	0	0	51	66	89	94	110	0	0	0	410

TABLE 159 -- NUMBER OF DEFICITS BELOW ELEVATION 99.2 FT. MSL, MODIFIED MARYLAND RELEASE SCHEME

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	3	8	4	0	0	0	0	0	0	0	0	0	15
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	4	5	0	0	0	0	0	0	0	0	0	0	9
1966	0	0	0	0	0	1	9	9	8	17	24	25	93
1967	25	4	1	0	0	0	0	0	0	0	0	0	30
1968	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	1	6	16	3	26
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	32	17	5	0	0	1	9	9	9	23	40	28	173

tions are shown in Table 160. The results of the simulation of the original and modified schemes are summarized in Table 161 for comparison with Tables 141 and 154.

The number of days less than the two control elevations increases for this modified scheme, in comparison to the original scheme. The minimum pool elevation increases for the modified scheme compared to the original scheme. The major factor of significance is that the amount of peaking power generation available decreases by about 2% for the modified scheme in comparison with the original scheme.

I. Limitations of Computer Model

Certain problems with the computer program were noted in Section IV.D.1. particularly with regard to the use of the project operating curves. Two meetings were held with Philadelphia Electric Company in December 1978 and January 1979 at which these problems were discussed. As a result it appears that the operating curves may not accurately represent actual operations. The company has stated that under no circumstances would the pool be allowed to go below elevation 104 ft. msl approximately, and under normal conditions the pool would be maintained above elevation 107 ft. msl approximately. The fact that the base case shows pool elevations below 99.2 ft. msl indicates that the operating curves may be calling for too much generation. However, Philadelphia Electric Company has not been able to provide any suggestions for improving the model as of September 1979.

In addition, the procedure for modifying the operating curves is not entirely satisfactory. Under certain circumstances the modified operating curves may result in total daily outflow greater than that determined from the original operating curves. This is due to the shape of the original curves and the procedure for modifying those curves. The original and modified curves do not always maintain weekly flow balance using actual daily net inflows. The modified curves may increase the imbalance due to the assumptions made in the modification.

For these reasons, revisions may have to be made in the model. These revisions could result in changes in the values given, but may not affect the conclusions.

J. Effects of Baltimore Withdrawals on Low Flows

In Section IV.E.1. it was noted that the effect of the Baltimore withdrawal seems fairly small. The statement is correct if the effect is examined over an extended period. On the average, the effect is small. However, under low flow conditions the effect becomes significant. For example, a withdrawal of

TABLE 160 -- MINIMUM POOL ELEVATIONS
MODIFIED MARYLAND RELEASE SCHEME

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1961	106.47	106.30	107.23	107.23	105.83	104.39	106.35	106.02	105.28	105.17	103.73	101.70
1962	102.02	104.53	105.09	107.23	104.72	104.84	104.55	104.53	103.57	101.78	100.83	100.71
1963	98.40	98.16	98.02	104.16	103.92	106.62	106.45	106.35	106.29	106.24	105.48	105.67
1964	103.84	105.27	105.08	106.88	105.51	103.84	103.15	103.11	103.46	103.51	103.47	103.75
1965	98.56	96.88	105.15	103.23	102.14	103.20	103.05	102.76	102.68	102.57	100.82	99.77
1966	101.65	101.97	107.20	104.05	104.00	98.91	98.15	98.10	98.11	96.85	95.65	94.98
1967	96.84	98.59	98.79	106.00	105.10	105.02	103.11	101.07	100.68	101.31	99.61	105.85
1968	105.42	104.76	106.80	106.29	106.65	103.91	102.85	102.91	102.39	102.09	101.84	105.10
1969	104.73	105.74	104.90	105.40	105.25	105.19	104.00	104.26	105.39	105.38	105.04	104.54
1970	105.75	106.48	104.81	107.23	105.56	103.44	103.44	104.83	105.54	105.05	103.77	106.13
1971	103.68	104.64	107.23	104.41	103.05	100.68	99.49	99.32	99.09	97.39	96.95	98.11
1972	104.75	104.39	107.01	106.87	106.84	104.55	105.91	105.99	104.89	104.62	103.86	107.23
1973	103.16	104.64	105.47	105.22	104.56	105.36	103.70	102.77	104.15	103.52	101.62	99.51
1974	105.61	105.52	105.93	107.01	105.67	104.38	105.85	105.94	102.04	101.26	100.80	101.98

TABLE 161

SUMMARY OF RELEASE SCHEME RECOMMENDED
BY MARYLAND FISHERIES ADMINISTRATION

SCHEME (1)	NO. OF DAYS LESS THAN 107.2 (2)	NO. OF DAYS LESS THAN 99.2 (3)	MIN. POOL ELEV. FT.MSL (4)	TOTAL POWER AVAILABLE BILLION CFS FT. (5)	TOTAL PEAK POWER AVAIL. BILLION CFS FT. (6)	(6)÷(5) (7)	TOTAL POWER AS RATIO TO BASE
Base	362	56	96.10	13.444	13.444	1.00	
Original	405	118	95.87	13.407	9.447	0.705	0.997
Modified	410	173	94.98	13.405	9.239	0.689	0.997

500 mgd (775 cfs) is 48% of the historic minimum daily flow at Harrisburg. In order to examine the effect of the Baltimore withdrawal under low flow conditions, additional comparisons were made using two conditions: no minimum release; and the minimum release scheme described in Case 2 in Section IV.H.1. In both cases only periods when inflow was less than 2500 cfs were considered. Four different magnitudes of Baltimore withdrawal were considered: 0 mgd; 100 mgd (155 cfs); 250 mgd (388 cfs); and 500 mgd (775 cfs).

For the case of no continuous release the effect of Baltimore withdrawals on the number of days that the pool elevation is below either 107.2 or 99.2 feet msl is shown in Table 162. The effect on minimum pool elevation and total power generation is also shown. For Case 2 of Section IV.H.1. the same information is shown in Table 163.

Simulated outflows for the period September 10, 1964 through September 29, 1964 are shown in Table 164 for the case with no continuous release and increased Baltimore withdrawals. The incremental difference in simulated outflow resulting from an increase in release is also shown for each Baltimore withdrawal considered. The same information is shown in Table 165 for the case with continuous release corresponding to Case 2 of Section IV.H.1.

For the case with no continuous release the number of days counted at a level less than elevation 99.2 feet msl increases by about 50% as the Baltimore withdrawal increases from zero to 500 mgd (775 cfs). The number of days counted at a level less than elevation 107.2 ft. msl similarly increases. The minimum pool elevations decrease by about 0.7 feet. The total power generated decreases by 327 million cfs feet. The average outflow during the September 1964 low flow period also decreases by an amount approximately equal to the amount of the increased Baltimore withdrawal.

With the continuous release the situation is somewhat different. The number of days that pool elevation is less than 107.2 ft. msl and 99.2 ft. msl tends to stay constant or to decrease slightly as the magnitude of the Baltimore withdrawal increases. The minimum pool elevations also are approximately constant and the total power decreases by 318 million cfs feet. The incremental reduction in outflow again appears to be about equal to the increase in Baltimore withdrawal.

Thus it appears that the Baltimore withdrawal does have a significant effect on river flows downstream from Conowingo when natural flows are less than 2500 cfs.

TABLE 162

EFFECT OF INCREASED BALTIMORE WITHDRAWAL ON NUMBER OF DAYS LESS THAN CRITICAL POOL ELEVATIONS, MINIMUM POOL ELEVATIONS, AND TOTAL POWER GENERATION, NO CONTINUOUS RELEASE

BALTIMORE WITHDRAWAL (MGD)	NO. DAYS LESS THAN 107.2 FT. MSL	NO. DAYS LESS THAN 99.2 FT. MSL	MINIMUM POOL ELEVATION FT. MSL	TOTAL POWER BILLION CFS FT. (14 YRS.)
0	355	46	96.52	13.606
100	357	52	96.35	13.542
250	362	56	96.10	13.444
500	370	70	95.80	13.279

TABLE 163

EFFECT OF INCREASED BALTIMORE WITHDRAWAL ON NUMBER OF DAYS LESS THAN CRITICAL POOL ELEVATIONS, MINIMUM POOL ELEVATIONS, AND TOTAL POWER GENERATION WITH CONTINUOUS RELEASE AS RECOMMENDED BY FISHERY AGENCIES

BALTIMORE WITHDRAWAL (MGD)	NO. DAYS LESS THAN 107.2 FT. MSL	NO. DAYS LESS THAN 99.2 FT. MSL	MINIMUM POOL ELEVATION FT. MSL	TOTAL POWER BILLION CFS FT.
0	412	58	96.77	13.567
100	408	54	96.76	13.505
250	412	45	96.75	13.411
500	423	50	96.85	13.249

TABLE 164

EFFECT OF BALTIMORE WITHDRAWAL ON CONOWINGO OUTFLOW, SEPTEMBER 1964 NO CONTINUOUS RELEASE

DATE	INFLOW CFS	BALTIMORE WITH. = 0 MGD (1)	BALTIMORE WITH. = 100 MGD (2)	BALTIMORE WITH. = 250 MGD (3)	BALTIMORE WITH. = 500 MGD (4)	INCREMENTAL CHANGES IN OUTFLOW DUE TO INCREASED WITHDRAWAL (1)-(2) CFS	(2)-(3) CFS	(3)-(4) CFS
9/10/64	2370	3439	3186	2807	2175	253	379	632
11	2440	1311	1210	1059	806	101	151	253
12	2290	364	371	380	395	-7	-9	-15
13	1930	379	385	394	410	-6	-9	-16
14	2130	2767	2535	2187	1606	232	348	581
15	2010	2759	2513	2146	1533	246	367	613
16	1970	2959	2694	2297	1635	265	397	662
17	1950	2753	2500	2121	1489	253	379	632
18	1860	933	831	680	427	102	151	253
19	1830	383	389	398	414	-6	-9	-16
20	1520	395	401	411	426	-6	-10	-15
21	2120	2752	2520	2172	1591	232	348	581
22	2360	3313	3067	2700	2087	246	367	613
23	2120	3215	2950	2554	1892	265	396	662
24	2030	2884	2631	2252	1620	253	379	632
25	1990	1017	916	765	512	101	151	253
26	1810	384	390	399	415	-6	-9	-16
27	1450	398	404	414	429	-6	-10	-15
28	1880	2392	2160	1812	1231	232	348	581
29	2360	3313	3067	2700	2087	246	367	613
Avg.when inflow less than 2500 cfs	2021	1906	1756	1532	1159	150	224	373
Avg.when inflow less than 2000 cfs	1819	1199	1107	969	739	92	138	230

TABLE 165

EFFECT OF BALTIMORE WITHDRAWAL ON CONOWINGO OUTFLOW, SEPTEMBER 1964 WITH CONTINUOUS RELEASE

DATE	INFLOW CFS	BALTIMORE WITH. = 0 MGD (1)	BALTIMORE WITH. = 100 MGD (2)	BALTIMORE WITH. = 250 MGD (3)	BALTIMORE WITH. = 500 MGD (4)	INCREMENTAL CHANGES IN OUTFLOW DUE TO INCREASED WITHDRAWAL (1)-(2) CFS	(2)-(3) CFS	(3)-(4) CFS
9/10/64	2370	2218	2063	1831	1444	155	232	387
11	2440	2288	2133	1901	1514	155	232	387
12	2290	2138	1983	1751	1364	155	232	387
13	1930	1778	1623	1391	1004	155	232	387
14	2130	1978	1823	1591	1204	155	232	387
15	2010	1858	1703	1471	1084	155	232	387
16	1970	1818	1663	1431	1044	155	232	387
17	1950	1798	1643	1411	1024	155	232	387
18	1860	1708	1553	1321	934	155	232	387
19	1830	1678	1523	1291	904	155	232	387
20	1520	1368	1213	981	594	155	232	387
21	2120	1968	1813	1581	1194	155	232	387
22	2360	2208	2053	1821	1434	155	232	387
23	2120	1968	1813	1581	1194	155	232	387
24	2030	1878	1723	1491	1104	155	232	387
25	1990	1838	1683	1451	1064	155	232	387
26	1810	1658	1503	1271	884	155	232	387
27	1450	1298	1143	911	524	155	232	387
28	1880	1728	1573	1341	954	155	232	387
29	2360	2208	2053	1821	1434	155	232	387
Avg.when inflow less than 2500 cfs	2021	1869	1714	1482	1095	155	232	387
Avg.when inflow less than 2000 cfs	1819	1667	1512	1280	893	155	232	387

K. Financial Analyses

1. Proposal by Maryland Fishery Administration

The financial impact of the release scheme discussed in Section IV.H.2. was evaluated using the following assumptions.

a. Energy production from the Conowingo plant is used at the peak of the PJM load curve; thus,

b. PJM hourly running rates are the relevant values for evaluating changes in peak and base load generation at Conowingo;

c. The output of the Conowingo plant is such a small fraction of total PJM production that changes in the operating schedule at Conowingo do not affect the PJM running rates;

d. The required releases pass through the turbines, i.e., generate electrical energy.

The hourly running rates are the historical operating costs of the last increment of electric production added to the system.

The financial impact of the flow release scheme was estimated in the following manner:

a. Determine the value of average monthly production of energy in the absence of a release requirement for each month of the year, based on results from the hydrologic simulation model.

b. Deduct the value of any peaking generation remaining, as determined from the simulation model after imposition of the release requirement, from the monthly production.

c. Deduct the value of generation that the release requirement causes to be moved to the base period from the peaking period, as determined from the hydrologic model.

d. Add a charge for the megawatts of capacity lost from the peaking period.

e. The net of the above four items is the monthly cost of losing peaking capability because of the release requirement. Sum over the twelve months to obtain the annual cost.

The monthly energy production figures without the release requirement are shown in Table 166 in cfs-feet.

TABLE 166

MONTHLY TOTAL POWER OUTPUT

BASE CASE (cfs-ft.x 10^8)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEARLY TOTAL
1961	0.2965	0.7530	2.0386	1.9851	1.4932	0.6849	0.3685	0.3617	0.2062	0.1083	0.2473	0.3910	8.9343
1962	0.8360	0.6209	1.9076	1.9198	0.7014	0.2329	0.0999	0.1224	0.0844	0.5124	0.7741	0.5379	8.3495
1963	0.6159	0.3888	1.8205	1.2469	0.9131	0.4921	0.2074	0.1231	0.1000	0.0672	0.1612	0.5207	6.6569
1964	0.9719	0.7557	1.7982	1.7418	1.0660	0.2927	0.1619	0.1076	0.0540	0.0659	0.0672	0.2397	7.3225
1965	0.4715	1.0488	1.1683	1.4879	0.7523	0.2592	0.0949	0.1132	0.1164	0.2463	0.2766	0.4107	6.4461
1966	0.4308	0.8828	1.8972	0.9384	1.5558	0.4461	0.1112	0.0928	0.1257	0.1506	0.2950	0.8090	7.7354
1967	015449	0.7086	1.7491	1.5598	1.7352	0.5079	0.3935	0.5637	0.2581	0.7159	1.1577	1.3137	11.2080
1968	0.5202	0.9678	1.1953	0.9359	1.2473	1.3048	0.4963	0.1531	0.3545	0.1971	1.0213	0.9482	9.3419
1969	0.6599	0.7168	0.7569	1.5513	0.9435	0.5259	0.4163	0.4871	0.1709	0.1389	0.7038	0.9098	7.9812
1970	0.5119	1.4744	1.2666	2.1857	1.1803	0.5564	0.5643	0.2783	0.2315	0.4960	1.3812	1.2022	11.3289
1971	0.7475	1.2796	2.0227	1.6316	1.1985	0.3901	0.1854	0.3402	0.7809	0.2536	0.4420	1.4043	10.1766
1972	1.2554	0.7783	2.1284	1.8307	1.8334	1.3339	1.4785	0.3765	0.1916	0.1971	1.3666	2.0523	14.8227
1973	1.3735	1.1910	1.5775	1.6645	1.6299	0.9703	0.5684	0.3885	0.3934	0.3866	0.7036	1.7772	12.6243
1974	1.6942	1.1340	1.5861	1.8554	1.0842	0.4838	0.6083	0.2744	0.5345	0.3130	0.5760	1.3701	11.5140
TOTAL	10.9301	12.7005	22.9130	22.5348	17.3341	8.4810	5.7548	3.7826	3.1021	3.8489	9.1736	13.8868	134.4423
AVG.	0.7807	0.9072	1.6366	1.6036	1.2382	0.6058	0.4111	0.2702	0.2216	0.2749	0.6553	0.9919	9.6030

Since the simulation program explicitly assumes a daily load curve of zero slope and extending over the entire 24-hour period, the simulation results may also be expressed in volumetric terms as cfs day feet. These figures were converted to units of megawatt hours per month by multiplying by an efficiency of 90%, and unit weight of water of 62.4 lbs./cu. ft. with appropriate conversion of the units. For this base case total power is equivalent to peaking power.

Table 167 gives the total power produced (base + peak) when the Maryland flow release requirement is imposed. The base load generation is derived from the flow devoted to the continuous release. Comparison of Tables 166 and 167 (or line 3 of Table 169) shows that total power remains essentially unchanged when the continuous release is made.

Table 168 shows the peak power capacity remaining after the flow release requirement has been met. Table 169 summarizes the relationships between base, total and peak production.

In Table 170 the average total monthly production is broken down into hours per day of plant operation on the following basis. Convert MWH per month to MWH per week (lines 1-3 of Table 170). Following the procedure used in an industry model for dispatching hydropower (7), divide the weekly energy by five days to obtain daily energy. The number of hours per day that generation will occur is determined by dividing the daily production by the plant capacity, 512 MW (lines 4 and 5). If the number of hours per day of operation exceeds 18, indicating generation during the off peak period, recompute on the basis of operating 7 days per week (lines 6 and 7).

Working back through the hours per day and the days per week of operation, calculate the hours per month the plant would operate without a flow release (lines 8 and 9). Using the percentage of peaking capability lost because of the flow release (from line 7, Table 169), calculate the peaking hours lost, i.e., moved to the base period, the peaking hours remaining, and the total off-peak generating period (lines 10-13 of Table 170).

Three relevant time periods have been determined: the number of hours per month the plant would operate without a flow release, the number of peak load generating hours with the release and the number of off-peak generating hours with the release. The computation of a weighted average running rate for each time period is shown in Table 171, using March 1978 PJM running rate data as an example. The mid-point of each price interval is used, weighted by the number of hours in the interval. Since it was assumed that all production without the re-

TABLE 167

TOTAL POWER OUTPUT FOR MARYLAND RELEASE SCHEME

(cfs-ft.x 10^8)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEARLY TOTAL
1961	0.2989	0.7618	2.0388	1.9840	1.4920	0.6837	0.3617	0.3658	0.2086	0.1072	0.2483	0.3896	8.9404
1962	0.7992	0.6153	1.9088	1.9216	0.6889	0.2367	0.1009	0.1202	0.0941	0.5156	0.7752	0.5495	8.3260
1963	0.5828	0.3670	1.7977	1.2450	0.8991	0.4890	0.2078	0.1269	0.1010	0.0643	0.1656	0.5229	6.5691
1964	0.9873	0.7533	1.7975	1.7413	1.0715	0.2956	0.1562	0.1091	0.0489	0.0672	0.0674	0.2292	7.3245
1965	0.4979	0.9985	1.1761	1.5003	0.7581	0.2629	0.0973	0.1139	0.1152	0.2591	0.2823	0.4092	6.4709
1966	0.4712	0.8958	1.8994	0.9315	1.5366	0.4441	0.1070	0.0823	0.1153	0.1444	0.2760	0.7524	7.6559
1967	0.5084	0.7132	1.7512	1.5557	1.7338	0.4995	0.4033	0.5634	0.2559	0.7161	1.1584	1.3214	11.1804
1968	0.5155	0.9588	1.2175	0.9332	1.2537	1.3011	0.4891	0.1530	0.3519	0.1912	1.0172	0.9533	9.3356
1969	0.6513	0.7188	0.7556	1.5495	0.9459	0.5320	0.4238	0.4927	0.1709	0.1379	0.7154	0.9057	7.9996
1970	0.5213	1.4855	1.2574	2.1855	1.1713	0.5538	0.5463	0.2813	0.2272	0.4918	1.3854	1.2002	11.3072
1971	0.7399	1.2649	2.0246	1.6278	1.2013	0.3847	0.1819	0.3289	0.2695	0.2478	0.4271	1.3917	10.0904
1972	1.2480	0.7781	2.1296	1.8301	1.8380	1.3280	1.4782	0.3763	0.1932	0.1972	1.3660	2.0527	14.8154
1973	1.3601	1.1724	1.5841	1.6611	1.6176	0.9674	0.5674	0.3794	0.3975	0.3861	0.6948	1.7659	12.5539
1974	1.6916	1.1259	1.5768	1.8583	1.0748	0.4911	0.6055	0.2786	0.5433	0.3126	0.5766	1.3722	11.5071
TOTAL	10.8734	12.6093	22.9151	22.5249	17.2826	8.4696	5.7264	3.7718	3.0925	3.8385	9.1557	13.8159	34.0764
AVG.	0.7767	0.9007	1.6368	1.6089	1.2345	0.6050	0.4090	0.2694	0.2209	0.2742	0.6540	0.9868	9.5769

NOTE: This table was based on a slightly different simulation of the Maryland Release Scheme from that discussed in Section IV.H.2. The differences are very small.

TABLE 168

PEAKING POWER OUTPUT FOR
MARYLAND RELEASE SCHEME (cfs-ft.x 10^8)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	YEARLY TOTAL
1961	0.0632	0.5186	1.6329	1.5941	1.0762	0.4425	0.2607	0.2647	0.1107	0.0140	0.1545	0.1389	6.2709
1962	0.4210	0.2758	1.5011	1.5307	0.2966	0.0445	0.0177	0.0335	0.0155	0.4182	0.6821	0.2923	5.5289
1963	0.2430	0.0665	1.4204	0.8443	0.4822	0.2422	0.1050	0.0275	0.0165	0.0134	0.0782	0.3038	3.8430
1964	0.6293	0.3715	1.4075	1.3434	0.6738	0.0793	0.0580	0.0249	0.0104	0.0131	0.0153	0.0495	4.6762
1965	0.1581	0.6717	0.7619	1.1147	0.3633	0.0535	0.0173	0.0277	0.0305	0.1634	0.1904	0.1547	3.7071
1966	0.1610	0.6172	1.4884	0.5276	1.1278	0.2116	0.0259	0.0165	0.0417	0.0527	0.1892	0.5185	4.9781
1967	0.1986	0.3644	1.3566	1.1581	1.3241	0.2558	0.3051	0.4686	0.1632	0.6223	1.0655	1.0490	8.3313
1968	0.1487	0.5784	0.8391	0.5244	0.8340	1.0669	0.3932	0.0549	0.2578	0.0941	0.9248	0.6873	6.4036
1969	0.2281	0.3420	0.4358	1.1502	0.5255	0.2879	0.3240	0.3931	0.0723	0.0355	0.6193	0.6454	5.0590
1970	0.1085	1.1131	0.8440	1.8004	0.7536	0.3150	0.4487	0.1816	0.1304	0.3929	1.2927	0.9268	8.3077
1971	0.3407	0.9267	1.6183	1.2308	0.7947	0.1526	0.0875	0.2349	0.1786	0.1549	0.3393	1.1233	7.1823
1972	0.8345	0.3847	1.7272	1.4345	1.4270	1.0978	1.3810	0.2763	0.0964	0.0972	1.2728	1.7891	11.8186
1973	0.9535	0.7959	1.1720	1.2676	1.2127	0.7277	0.4699	0.2823	0.3016	0.2877	0.6028	1.5053	9.5789
1974	1.2800	0.7489	1.1640	1.4630	0.6540	0.2466	0.5052	0.1775	0.4491	0.2154	0.4843	1.1012	8.4892
TOTAL	5.7682	7.7754	17.3692	16.9838	11.5455	5.2239	4.3992	2.4640	1.8747	2.5748	7.9112	10.2851	94.1748
AVG.	0.4120	0.5554	1.2407	1.2131	0.8247	0.3731	0.3142	0.1760	0.1339	0.1839	0.5651	0.7346	6.7268

NOTE: This table was based on a slightly different simulation of the Maryland Release Scheme from that discussed in Section IV.H.2. The differences are very small.

TABLE 169

PEAKING CAPACITY LOST BECAUSE OF MARYLAND RELEASE SCHEME

AVG.MWH/MO.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
1. Base	142381	165452	298477	293552	225818	110483	74975	49278	40415	50135	119511	180899
2. Total	141651	164266	298513	293424	225143	110337	74592	49132	40287	50007	119274	179969
3. Total Base	.995	.993	1.000	1.0	.997	.999	.995	.997	.997	.997	.998	.995
4. Peak	75139	101292	226274	221058	150405	68044	57303	32098	24420	33539	103061	133973
5. Loss (2.-4.)	65512	62974	72239	72366	74738	42293	17289	17034	15867	16468	16213	45996
6. Peak Total	.530	.617	.758	.753	.668	.617	.768	.653	.606	.671	.864	.744
7. % Loss 1.00-(6.)	.47	.383	.242	.247	.332	.383	.232	.347	.394	.329	.136	.256

NOTE: (2.-4.) denotes the value in line 2 minus the value in line 4.

TABLE 170
OPERATING HOURS FOR EACH MONTH

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
1. Avg. Prod. for Month (MWH)	141651	164266	298513	293424	225143	110337	74592	49132	40287	50007	119274	179969
2. Wks./Month	4.4286	4.0306	4.4286	4.2857	4.4286	4.2857	4.4286	4.4286	4.2857	4.4286	4.2857	4.4286
3. MWH/Wk. (1.÷2.)	31985.7	40754.7	67406.2	68465.8	50838.4	25745.4	16843.2	11094.3	9400.3	11291.8	27830.7	40637.9
4. (3)÷ 5 days	6397	8150.9	13481	13693	10168	5149	3369	2219	1880	2258	5566	8128
5. (4)÷ 512 MW	12.5hrs.	15.9hrs.				10.1hrs.	6.6hrs.	4.3hrs.	3.7hr.s	4.4hrs.	10.9hrs.	15.9hr
6. (3)÷ 7 days			9629	9781	7263							
7. (6)÷ 512			18.8hrs.	19.1hrs.	14.2hrs.							
8. Days/Mo. (2.x 5.or 7.)	22.14	20.15	31	30	31	21.43	22.14	22.14	21.43	22.14	21.43	22.14
9. Hrs./Mo. (5.or 7.x 8.)	277	320	583	573	440	216	146	95	79	97	234	352
10. % Peaking Lost	.47	.383	.242	.247	.332	.383	.232	.347	.394	.329	.136	.256
11. Hours Lost (9.x 10.)	130	123	141	142	146	83	34	33	31	32	32	90
12. Peak Hours Remaining	147	197	442	431	294	133	112	62	48	65	202	262
13. Total Hours. in Month	597	475	302	288	450	587	632	682	672	680	518	482
14. Off-Peak Hr. (13.-12.)	744	672	744	719	744	720	744	744	720	745	720	744

NOTE: (1.÷ 2.) denotes the value in line 1 divided by the value in line 2.

TABLE 171

COMPUTATION OF WEIGHTED AVERAGE RUNNING RATES FOR VARIOUS TIME PERIODS

(BASED ON PJM DATA FOR MARCH 1978)

1.	2.	3.	4.			5.		
RUNNING RATE INTERVALS ($/MWH)	MIDPOINT OF INTERVAL ($/MWH)	NO. OF HRS. SYSTEM OPERATED AT INDICATED RATE	INTERVALS ENCOMPASSED BY VARIOUS TIME PERIODS (HRS/MO.)			VALUATION OF EACH INTERVAL (2. x 4.)		
			NO RELEASE (ALL PEAK)	PEAK W/RELEASE	OFF-PEAK W/RELEASE	NO RELEASE	PEAK W/RELEASE	OFF-PEAK W/RELEASE
15.0 - 19.9	17.45	76			76			$1326.2
20.0 - 24.9	22.45	259	174	33	226	$ 3906.3	$ 740.85	$5073.7
25.0 - 29.9	27.45	102	102	102		$ 2799.9	$ 2799.9	
30.0 - 34.9	32.45	56	56	56		$ 1817.2	$ 1817.2	
35.0 - 39.9	37.45	98	98	98		$ 3670.1	$ 3670.1	
40.0 - 44.9	42.45	129	129	129		$ 5476.05	$ 5476.05	
45.0 - 49.9	47.45	13	13	13		$ 616.85	$ 616.85	
50.0 - 54.9	52.45	11	11	11		$ 576.95	$ 576.95	
		MONTHLY TOTAL:	583	442	302	$18863.35	$15697.9	$6399.9

6.

WEIGHTED AVERAGE RUNNING RATE ($/MWH) FOR:

NO RELEASE = $18863.35/583 = $32.356

PEAKING W/RELEASE = $15697.9/442 = $35.516

OFF-PEAK W/RELEASE + $6399.9/302 = $21.192

lease is peaking power, compute the weighted average of the "top" 583 hours of the running rate distribution. Similarly compute the weighted average rate for the 442 peaking hours remaining with the release, using the top of the distribution. The 302 hours of off-peak generation are the weighted average of that many hours from the bottom of the distribution. The same calculations were made for each of the other months of 1978.

Parties to the PJM Agreement are subject to several capacity obligations. If they fail to meet the obligation, they incur a charge; if they exceed the requirement, they are given a credit.

Under the Agreement the capacity requirements of the Interconnection are determined and allocated among the members. These amounts constitute the "contract capacity" of each member. If the member does not have that amount of capacity installed, they may purchase it from other members. The rate used for these transactions was \$22.63 per kilowatt per year (\$62 per megawatt per day) as of June 1, 1978.

In addition to the contract capacity, each member of the Interconnection has obligations to provide operating capacity (defined for the peak period as its estimated peak load plus its share of the required spinning reserve). Failure to meet the requirement for a given peak period means that a capacity charge will be imposed for that period. The capacity charge for a deficit in synchronized capacity can be as much as 120% of the highest cost capacity operated by the Interconnection.

Since the flow release requirement does not decrease the total capacity available to Philadelphia Electric Company, it was assumed that a contract capacity charge would not be imposed. However, the loss of peaking capacity associated with the flow release results in an operating capacity charge to the company. In the absence of any specific information about the magnitude of such a charge, it was valued at 120% of the <u>contract capacity charge</u>, i.e., (\$62/mw/day/24)(1.2) = \$3.10/mw/hr. The computations of capacity charges are shown in Table 172.

The net cost, in terms of peaking power foregone, of implementing the Maryland flow release scheme was computed as shown in Table 173. Basically, in Table 173 the following calculation is carried out for each month.

Net Cost of the Release =

(value of peaking power without release) -

TABLE 172

ESTIMATED CAPACITY CHARGES FOR PEAK CAPACITY LOST TO FLOW RELEASE

MONTH	MONTHLY PEAK (MW) 1/	% PEAK CAPACITY LOST TO RELEASE 2/	MW LOST	COST/HOUR AT $3.10/MW/HR. 3/	PEAKING HOURS LOST TO RELEASE 4/	$/MONTH
Jan.	484	47.0	227.5	$705.19	130	$91,674
Feb.	502	38.3	192.3	596.02	123	73,311
Mar.	505	24.2	122.2	378.85	141	53,418
Apr.	505	24.7	124.7	386.68	142	54,908
May	499	33.2	165.7	513.57	146	74,981
Jun.	478	38.3	183.1	567.53	83	47,105
Jul.	425	23.2	98.6	305.66	34	10,392
Aug.	421	34.7	146.1	452.87	33	14,945
Sep.	457	39.4	180.1	558.18	31	17,304
Oct.	415	32.9	136.5	423.26	32	13,544
Nov.	482	13.6	65.6	203.21	32	6,503
Dec.	489	25.6	125.2	388.07	90	34,926
					ANNUAL TOTAL	$493,011

1/Avg. of monthly peaks at Conowingo: 1965-78 (from Form 1's, p. 431)
2/From Table 169, line 7
3/120% x $62/MW/Day (see PJM agreement, Sch. 4.01 (Rev.No. 1) § a)
4/From Table 170, line 11

TABLE 173

NET COST OF CONTINUOUS FLOW RELEASE AT CONOWINGO

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
1. Production (MWH)	141,651	164,266	298,513	293,424	225,143	110,337	74,592	49,132	40,287	50,007	119,274	179,969
2. Hours/Month	277	320	583	573	440	216	146	95	79	97	243	352
3. Avg.Run.Rate for 2. ($/MWH)	47.992	41.013	32.356	24.919	27.598	31.362	34.916	45.187	38.399	37.089	33.993	32.18
4. Value Production w/o Release (1.x 3.)	6798115	6737042	9658687	7311832	6213497	3460389	2604454	2220128	1546981	1854710	4054481	5791402
5. Peak MWH w/Release	75,139	101,292	226,274	221,058	150,405	680,044	57,303	32,098	24,420	33,539	103,061	133,973
6. Running Rate for 5. ($/MWH)	55.307	45.013	35.516	27.148	30.154	35.458	37.182	47.773	42.033	39.373	35.321	34.511
7. Value of Peak MWH (5.x 6.)	4155713	4559457	8036347	6001283	4535312	2412704	2130640	1533418	1026446	1320531	3640218	4623542
8. MWH Moved to Base (1.- 5.)	66,512	62,974	72,239	72,366	74,738	42,293	17,289	17,034	15,867	16,468	16,213	45,29
9. Running Rate for 8. ($/MWH)	27.224	26.997	21.192	16.642	18.194	18.949	18.376	22.083	19.712	22.413	20.944	20.04
10. Value of Base MWH (8.x 9.)	1810723	1698787	1530889	1218783	1359783	801410	317703	376162	312770	369097	339565	92189
11. Capacity Charge	91,674	73,311	53,418	54,908	74,981	47,105	10,392	14,945	17,304	13,544	6,503	34,92
12. Net Cost of Release (4.- 7.- 10.+ 11.)	923,371	552,109	144,869	146,669	393,383	293,380	166,503	325,493	225,069	178,626	81,201	280,88

SUM OF LINE 12: $3,711,561

NOTE: (1. ÷ 3.) denotes the value in line 1 divided by the value in line 3.

(value of peaking power remaining with release) -

(value of peaking power moved to off-peak with release) +

(charge for peaking capacity lost).

The computations are summarized in Table 174.

The average annual cost of the release scheme is $3.7 million which represents the average cost to Philadelphia Electric Company, in constant 1978 dollars, of implementing the Maryland flow scheme, if the 1961-1974 flow sequence were to reoccur.

While this interpretation appears quite guarded, it should be remembered that the 1961-1974 hydrologic record includes "normal", "high" and "low" flow events and may be viewed as being a "typical" or "representative" period.

By way of perspective, if the annual cost is allocated to the three major groups of ratepayers in proportion to the kilowatt-hours of energy sold to each group, the annual cost per customer based on data obtained from FERC Form 1 (8) in each group is as follows:

Ratepayer Group	Proportion of Energy Sold to Ratepayer Group	Cost Share of Release ($/Year/Customer)
Residential	0.2991	$ 0.98
Commercial	0.1097	3.58
Industrial	0.5912	385.10
	1.0000	

2. Maryland Proposal Modified by Other Fishery Agencies

No financial analysis was made for the modified release scheme discussed in Section IV.H.3. The modification of the release scheme has relatively little effect on the amount of peaking power generation available, and thus is expected to have little additional financial impact on the power company or the rate payer.

L. Effect of New Turbines on Frequency of Dewatering

As a result of the above studies a question was raised regarding the change in frequency of dewatering during the anadromous spawning period resulting from installation of the new turbines. In order to answer that question, the average daily

TABLE 174

VALUE OF PEAK HOUR PRODUCTION LOST TO IMPLEMENT CONTINUOUS RELEASE REQUIREMENT

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Production (MHW)	141,651	164,266	298,513	293,424	225,143	110,337	74,592	49,132	40,287	50,007	119,274	179,969
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Value of Production w/o Release (10^3)	6,798	6,737	9,659	7,312	6,213	3,460	2,604	2,220	1,547	1,855	4,054	5,791
minus												
Value of Peak Production Remaining w/ Release (10^3)	4,156	4,559	8,036	6,001	4,535	2,413	2,131	1,533	1,026	1,321	3,640	4,624
minus												
Value of Production Moved From Peak to Base to Meet Release Requirements (10^3)	1,811	1,699	1,531	1,219	1,360	801	318	376	313	369	340	922
plus												
Charge for Peak Capacity Lost (10^3)	92	73	53	55	75	47	10	15	17	14	7	35
equals												
Net Cost of Release Requirement (10^3)	923	552	145	147	393	293	165	326	225	179	81	280

Sum of Monthly Net Costs -- $3,709,000

flow duration curves for the months of April, May and June for the entire period of record at Marietta were studied. These particular months were chosen because they are the months most important for the anadromous fishery.

The original installation had a plant capacity of 35,000 cfs which means that there was no control of flows in excess of 35,000 cfs, and therefore no dewatering would result from such flows. Only flows less than 35,000 cfs would be affected by the plant operation with the original configuration.

The plant capacity at most efficient gate with the new turbines is 72,000 cfs. By the same logic, only flows less than 72,000 cfs will be affected by plant operation with this present configuration. Therefore, the percentage of time that flow is less than 35,000 cfs can be compared to the percentage of time flow is less than 72,000 cfs and the difference in percentage of time is a measure of the impact of the increased capacity on the frequency of dewatering during the anadromous spawning period. This difference in percentage time represents the increase in percentage of time that the increased capacity results in dewatering the reach downstream from the dam. These values are shown in the following table.

Month	% of Days Flow Less Than 35,000 cfs	% of Days Flow Less Than 72,000 cfs	Increase In % Time
April	14	58	44
May	44	81	37
June	81	96	15

It appears that the installation of the additional capacity has had considerable effect on the percentage of time that dewatering occurs. This in turn implies an impact on the spawning of the anadromous species during this period.

The above analysis shows only average effects. A more refined analysis would probably show that the increased dewatering occurs in some years and not others. It may be desirable to examine the flow records and tabulate those periods of time when the flow was less than the plant capacity for the two different configurations in order to obtain a more detailed picture of the effect of the increased plant capacity on anadromous spawning.

V. SUMMARY AND CONCLUSIONS

The Commission staff has made two general types of investigations of the hydrologic effects of Conowingo Dam. The first type of investigation was a statistical analysis of the stream-

flow data for the period 1961 through 1974 at four locations and 1967 through 1974 at a fifth location. Only the months of March through October were considered. The purpose of these studies was: 1) to determine whether there were inconsistencies in the data which might invalidate further comparisons; and 2) determine the effect of Conowingo project operation on flows downstream of the dam.

The mean, standard deviation, coefficient of variation and correlation coefficients of average daily flows for each month were studied for different years and also pooled across years. Comparisons were made among the different locations. Also the differences between daily flow values at different pairs of stations were compared across years. In general the results showed a reasonable degree of consistency. The major problem appears to be a loss of flow between Marietta and Conowingo when data furnished by Philadelphia Electric Company is used to represent releases from Conowingo. The results also demonstrated that Conowingo does affect the low flows as indicated by the coefficient of variation at the several locations and the correlation coefficient under low flow conditions. Also flow duration plots show the effect of the dam operations at low flow. In particular, the Philadelphia Electric Company data for outflow from Conowingo results in a flow duration curve much steeper for inflows less than 5000 cfs in comparison with the Marietta flow duration curve. This is significant because 5000 cfs is approximately the capacity of one small turbine operated at most efficient gate.

The second type of investigation was a simulation analysis to demonstrate the effects of different continuous release requirements on all uses of the Conowingo pool including power generation, water supply and the fishery. A large number of different schemes were simulated for various purposes as well as in response to requests from other parties. The effect of different levels of withdrawal for Baltimore water supply were also considered.

As a result of early studies it was concluded that an effort should be made to quantify the needs of the fishery. As a result, the Commission staff in cooperation with U.S. Fish and Wildlife Service, Maryland Wildlife Administration, Pennsylvania Fish Commission, and U.S. Geological Survey conducted a study to determine the levels of flow which should be maintained downstream from Conowingo Dam. The details of the study are described by Jackson and Lazorchick (6).

As a result of that study the state and Federal fishery agencies recommended several different continuous release schemes as shown in Table 175 and these schemes were also simulated. Schemes 1, 2 and 3 include a specification that if the net inflow (observed flow at the USGS gage at Marietta,

TABLE 175

MINIMUM RELEASE SCHEMES
SUGGESTED BY FISHERY AGENCIES

MONTH	CONTINUOUS MINIMUM RELEASE (CFS)				
	SCHEME 1	SCHEME 2	SCHEME 3	SCHEME 4	SCHEME
January	17600	12000	17600	15000	15000
February	17600	12000	10600	15000	15000
March	15000	12000	5000	15000	15000
April	15000	12000	65000	15000	15000
May	15000	12000	39500	15000	15000
June 1-7	15000	12000	15000	12700	12700
June 8-14	15000	12000	15000	10400	10400
June 15-21	15000	12000	15000	8100	8100
June 22-28	15000	12000	15000	5800	5800
June 29-30	15000	12000	15000	3500	5000
July	17600	12000	12600	3500	5000
August	12000	5000	12000	3500	5000
September	12000	5000	12000	3500	5000
October	12000	5000	12000	3500	5000
November	17600	12000	17600	3500	5000
December 1-7	17600	12000	17600	5800	5800
December 8-14	17600	12000	17600	8100	8100
December 15-21	17600	12000	17600	10400	10400
December 22-28	17600	12000	17600	12700	12700
December 29-31	17600	12000	17600	15000	15000

Pa. minus withdrawals for Chester and Baltimore water supply and for Peach Bottom consumptive use), is less than the specified release, the required continuous release is equal to the net inflow. Schemes 4 and 5 include a specification that if 80% of the net river flow is equal to or less than the required release the release is set equal to 80% of the net inflow.

Schemes 1 and 2 represent recommendations in the absence of fish passage facilities. For Scheme 1, the flow for each month was chosen to maximize usable habitat for all target species without decreasing the habitat for any species by more than 50% of the optimum. Scheme 2 represents the minimum acceptable flow to maintain some fishery downstream from Conowingo considering historical flow records. Scheme 3 is based on assigning the highest priority to attraction and passage flows for anadromous species. Scheme 4 was developed in an effort to follow the natural flow cycle as closely as possible and is based on having natural flow in excess of the required release about 90% of the time. Scheme 5 is a modification of Scheme 4 designed to provide habitat more nearly approaching the optimum level of habitat for all resident species during the summer and fall low flow periods.

The results of the simulations of the schemes proposed by the fishery agencies are summarized in Table 176 in the form of impacts on the number of days less than elevation 107.2 ft. msl and 99.2 ft. msl, the effect on minimum pool elevation and the effect on peaking power availability. Since the elevation 107.2 ft. msl is considered the desirable pool level for recreation use, the number of days less than that elevation represents an impact on recreation use. The smaller the number of days less than that elevation, the less the impact on recreation use. Elevation 99.2 ft. msl represents the level at which Peach Bottom must be shut down. Thus, the number of days less than that elevation represents an impact on Peach Bottom operations specifically, and possibly Chester and Baltimore withdrawals. The minimum pool elevation impacts on water supply withdrawals and also represents an impact on pool fishery and to some degree on recreation uses and access. The peaking power generation lost represents an impact on Conowingo power generation.

In summary, Scheme 3 produces the greatest impact on other uses. Scheme 1 results in the next largest impact on recreation use and peaking power generation. However, the impact on pool fishery and water supply withdrawals is least for Scheme 1 compared to the other schemes. Scheme 2 has the least impact on recreation use and about the same effect on pool fishery and Peach Bottom operations as Scheme 1.

Scheme 4 has the least effect on recreation use and on peaking power generation of any scheme, but considerably more

TABLE 176

SUMMARY OF SIMULATIONS USING
MINIMUM RELEASES RECOMMENDED BY FISHERY INTERESTS

SCHEME (1)	NO.OF DAYS LESS THAN 107.2 (2)	NO.OF DAYS LESS THAN 99.2 (3)	MIN. POOL ELEV. (4)	TOTAL POWER AVAILABLE BILLION CFS FEET (5)	TOTAL PEAK POWER AVAIL. BILLION CFS FEET (6)	PEAK POWER GENERATION LOST AS % OF TOTAL POWER (7)	TOTAL POWER AS RATIO TO BASE TOTAL (5) ÷ BASE (8)
Base	362	56	96.10	13.444	13.444	1.00	---
1	426	17	97.03	13.436	7.712	0.426	0.999
2	412	45	96.75	13.411	9.100	0.321	0.997
3	446	258	86.35	13.382	5.566	0.584	0.995
4	395	153	94.93	13.408	9.418	0.298	0.997
5	412	208	94.86	13.404	9.13	0.319	0.997

impact on Peach Bottom operations and pool fishery compared to Scheme 1 or 2. Scheme 5 has slightly more impact on Peach Bottom operations, pool fishery, and Conowingo generation than Scheme 4.

Before proceeding it should be noted that the hydrologic model used to generate this data includes approximations to actual operations which tend to produce pool elevations which are too low in comparison with the operating criteria used by the power company. The computed pool elevations are suspect and in particular the number of days less than the specified control elevations are questionable. It is not known whether this will affect the peaking power calculations, but if it does the effect is expected to be small. A more detailed model is necessary. Until such time as such a model is developed, the numbers shown in Table 176 should be considered to be at best an indication of direction of impact and relative magnitude of that impact.

For that reason the staff recommends either Scheme 4 or Scheme 5 because those schemes appear to be generally satisfactory for the fishery downstream from the dam, and have the smallest impact on peaking power generation. There seems to be relatively little difference between those two schemes. However, Scheme 5 will provide a small amount of additional flow during the low flow months in comparison with Scheme 4 and considerable improvement in the habitat should be experienced during that period. That scheme appears to be acceptable to all the fishery agencies.

It has been estimated that Scheme 4 will have an average annual financial impact of about $3.7 million on the power company. The estimated average annual increase in cost for each ratepayer group is shown in the following tables:

Ratepayer Group	Cost Share $/Year/Customer
Residential	0.98
Commercial	3.58
Industrial	385.10

Thus, the cost of Scheme 4 to the ratepayer does not seem significant. The financial impact of Scheme 5 has not been calculated but considering the overall impact on peaking power generation, it is expected to be only slightly greater than the impact of Scheme 4.

The simulation analyses also were used to evaluate the effect of Baltimore water supply withdrawals on other uses of the pool. The effect of the Baltimore withdrawal is small if averaged over the entire period of study. However, the effect

becomes significant when natural flows are of the order of 2500 cfs or less.

As a result of questions raised by the simulation analysis, a storage yield analysis was made to determine how much water could be provided from the Conowingo storage under low flow conditions. The analysis showed that if the entire Conowingo storage were utilized, a flow equivalent to 1790 cfs could be provided from storage during the most critical period on record. The average outflow during this period would then be 4250 cfs. If only the increment of storage between elevation 99.2 ft. msl and 109.2 ft. msl were used, an average outflow of 2890 cfs could be provided of which 630 cfs would come from storage. This confirms that it is not possible to maintain a continuous release of the magnitude indicated in Table 175 by utilizing the storage, without creating a significant impact on other uses.

Finally, an additional analysis was made to show the effect of the installation in 1964 of the four new turbines on the frequency of dewatering of the area downstream from Conowingo during the anadromous spawning period. This analysis was based on flow duration curves and should be considered to represent long term averages, rather than specific years. The results demonstrated that there is a significant increase in percentage of time that dewatering would occur, as result of the increased capacity provided by the new turbines.

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